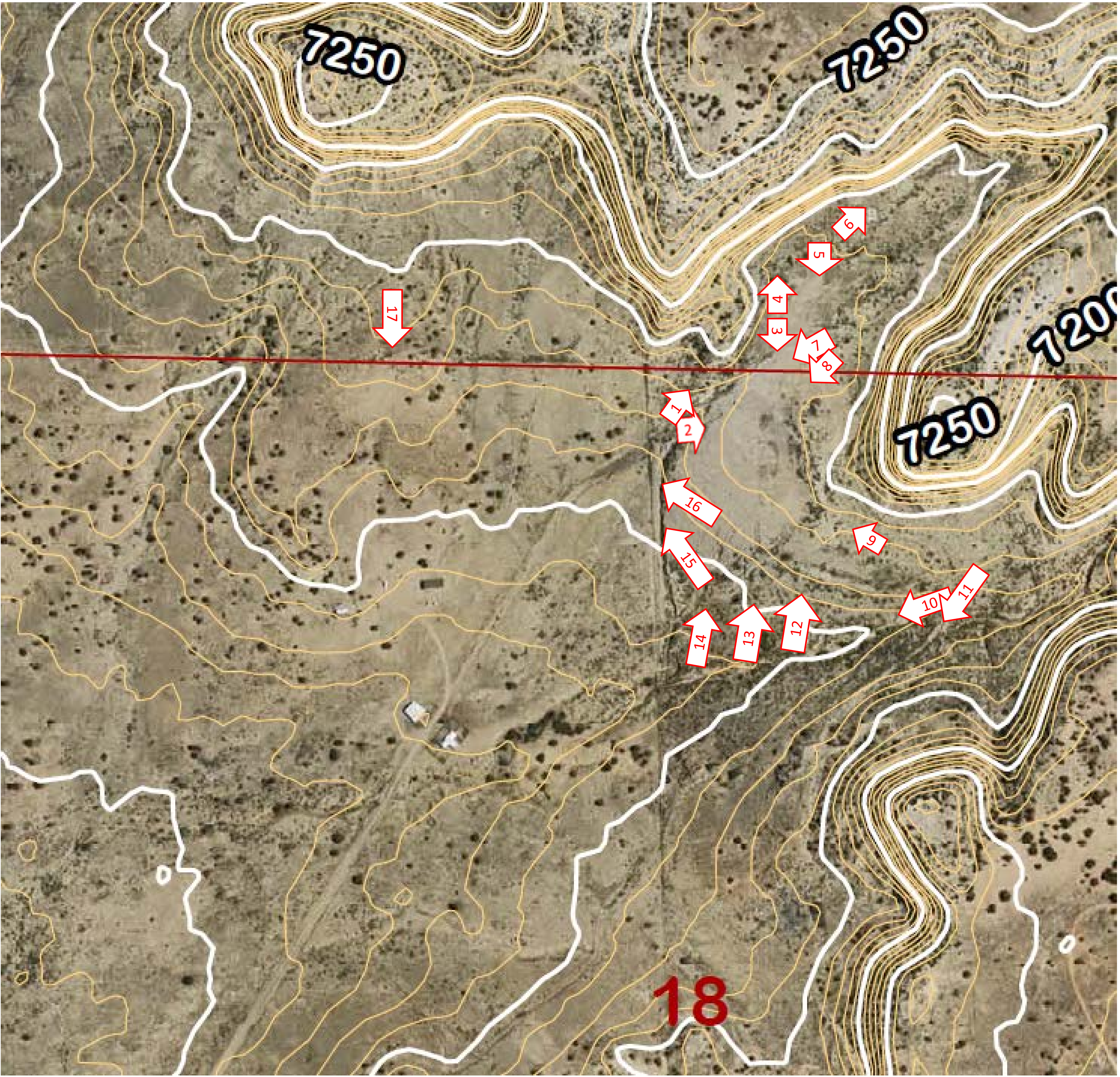
Appendix A

Geomorphological Survey Photographs



Johnny M
Photo Locations
9/19/2012

Site Visit by Alan
Kuhn and Mike
Schierman

Johnny M Photo Log and Comments
9/19/2012
Alan Kuhn

1. Fenceline arroyo (paralleling N-S property line fence at west side of property area), view north of headcut next to gate. Headcutting is active along main arroyo and east tributaries (Photo 2). The main arroyo follows the west side of the mine along the base of the mesa north to northing about at the office location.
2. Fenceline arroyo tributary east of Position 1, actively cutting into waste rock.
3. West side of mine, view south from safety station pad. This area is geomorphically stable; no headcutting.
4. West side of mine, view north from safety station pad.
5. View south, near the North Vent. Limit of waste rock and sediment pond is south of the cluster of trees, which are at the main shaft location.
6. NE of the North Vent in the mine, view NE to mesa slope talus.
7. North end of sediment pond from hoist area. Pond starts at center of photo and extends to the left. Pond basin is visible but has been backfilled.
8. South end of sediment pond from hoist area. South end of pond is at left center of photo.
9. View NW toward substation from east end of Pond 2.
10. View WSW along main arroyo from pipeline crossing. Note large vegetation in bottom of arroyo, indicating stable channel.
11. View at arroyo bottom from Position 10. Small brush stems are above sediment surface, and south bank is steep but stable.
12. View north to breach in sediment pond. Apparently, waste rock (visible in foreslope) was used for part of the pond containment.
13. Headcut in tributary arroyo into waste rock, viewed north.
14. Exposed concrete slab and waste rock north from main arroyo. Alluvial soil/ weathered shale in lower part of foreslope.
15. Degrading fenceline arroyo viewed NNW. Waste rock is in the entire eroded section, indicating that it was used to fill the original natural arroyo.
16. Degrading fenceline arroyo viewed NW near gate. Vegetation stems in the arroyo bottom are partially covered with sediment.
17. Potential cell location in NE NW NW of Section 18, view to south. Location is the high ground in the center of the picture and right of power pole. Hill is capped by a thin layer of iron-oxide cemented sandstone that might be durable enough for riprap.

Figure 1

Figure 2


Figure 3

Figure 4

Figure 5


Figure 6

Figure 7

Figure 8

Figure 9

Figure 10

Figure 11

Figure 12

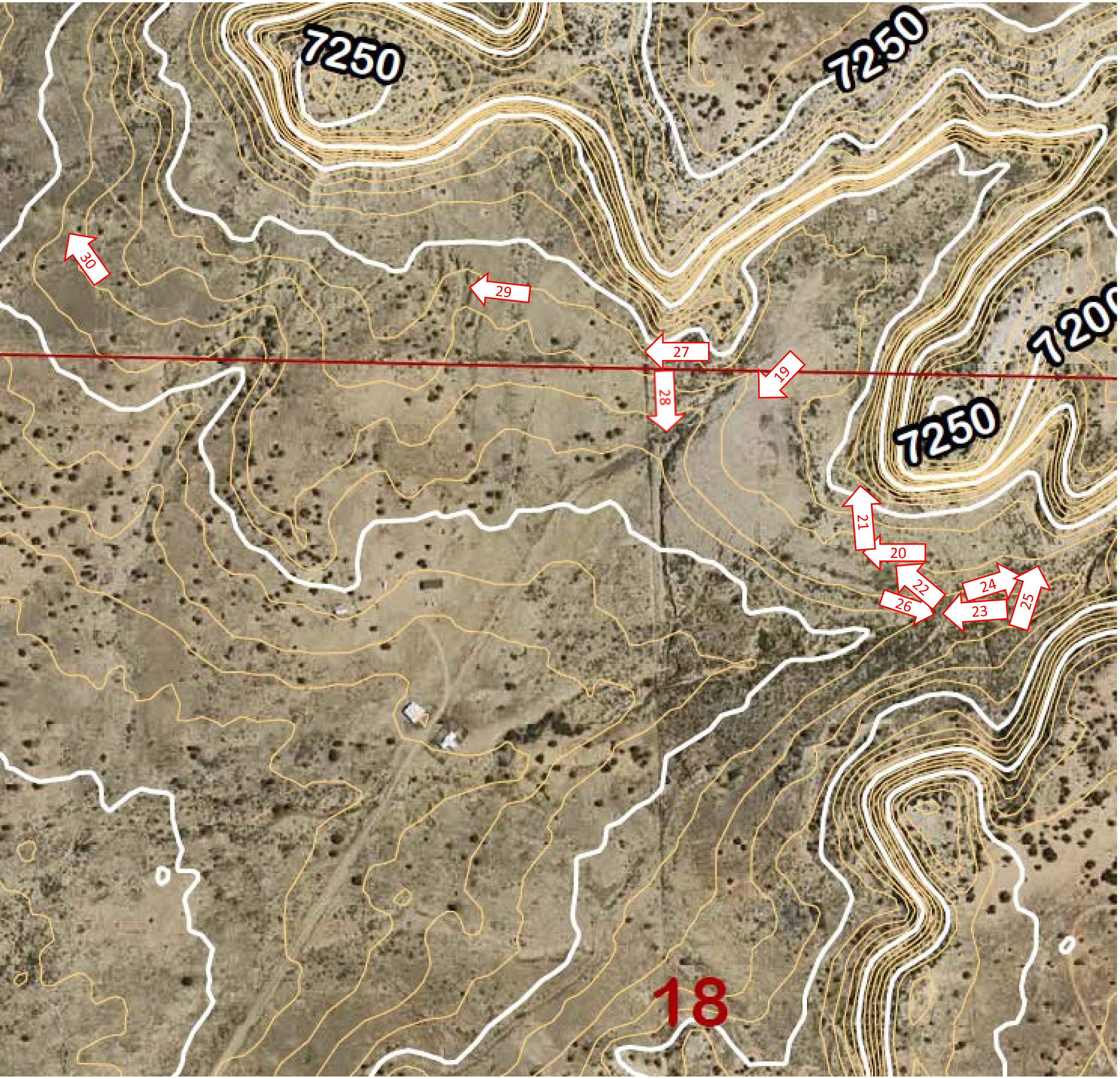

Figure 13

Figure 14

Figure 15

Figure 16

Figure 17



Johnny M
Photo Locations
9/8/2012

Site Visit by Alan
Kuhn and Mike
Schierman

Johnny M Mine Photo Log
9/8/2012
Alan Kuhn

19. View from NE corner of north sediment pond looking southwest
20. View from east end of south sediment pond looking west
21. View from east and south sediment pond looking north, substation on left
22. Old powder magazine south of the south sediment pond
23. Main arroyo looking west from the pipeline crossing
24. Main arroyo looking east from pipeline process
25. Canyons east of pipeline crossing at the top of the main arroyo watershed
26. View southeast from main arroyo at pipeline crossing
27. View west along north fence line of Section 18 from the NE corner of NW ¼
28. View south along fenceline between Lee ranch and Area C
29. View west of SW ¼ Section 7, north of Section 18 fenceline
30. View of area in SW ¼ of Section 7


Figure 19

Figure 20

Figure 21

Figure 22


Figure 23

Figure 24

Figure 25

Figure 26

Figure 27


Figure 28


Figure 29

Figure 30

Appendix B

Instrument Cailbration Forms

ERG

Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc.
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

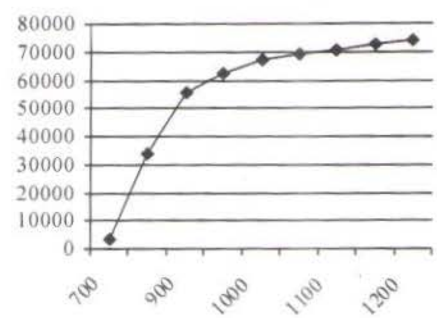
Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	117357
Detector:	Manufacturer:	Ludlum	Model Number:	44-10	Serial Number:	PR144055

☑ Mechanical Check ☑ Geotropism ☑ THR/WIN Operation ☑ Audio Check ☑ Battery Check (Min 4.4 VDC)
☑ F/S Response Check ☑ Meter Zeroed ☑ Reset Check HV Check (+/- 2.5%): ☑ 500 V ☑ 1000 V ☑ 1500 V
Source Distance: ☐ Contact ☑ 6 inches ☐ Other: Cable Length: ☐ 39-inch ☐ 72-inch ☑ Other: 10'
Source Geometry: ☑ Side ☐ Below ☐ Other: Temperature: 77 °F Relative Humidity 20 %
Threshold: 10 mV Window: Barometric Pressure: 24.75 inches Hg
Instrument found within tolerance: ☑ Yes ☐ No

Range/Multiplier	Reference Setting	"As Found Reading"		Meter Reading		Integrated 1-Min. Count	Log Scale Count	
x 1000	400	400	kcpm	400	kcpm	399863	400	kcpm
x 1000	100	100	kcpm	100	kcpm		100	kcpm
x 100	400	400	kcpm	400	kcpm	39983	400	kcpm
x 100	100	100	kcpm	100	kcpm		100	kcpm
x 10	400	400	kcpm	400	kcpm	3998	400	kcpm
x 10	100	100	kcpm	100	kcpm		100	kcpm
x 1	400	400	cpm	400	cpm	400	400	cpm
x 1	100	100	cpm	100	cpm		100	cpm

High Voltage	Source Counts	Background
700	3392	
800	33997	
900	55499	
950	62685	
1000	66991	
1050	68817	
1100	70399	
1150	72721	11330
1200	73884	

Voltage Plateau



Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV =1150

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ☑ 201932 Fluke multimeter serial number: ☐ 8749012
☐ Alpha Source: Th-230 @ 12,800 dpm (1/4/12) sn: 4098-03 ☑ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03
☐ Beta Source: Tc-99 @ 17,700 dpm (1/4/12) sn: 4099-03 ☐ Other Source:

Calibrated By: Calibration Date: 8-31-12 Calibration Due: 8-31-13

Reviewed By: Review Date: 9/4/12

ERG

Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc.
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	117357
Detector:	Manufacturer:	Ludlum	Model Number:	44-10	Serial Number:	PR144055

☑ Mechanical Check ☑ Geotropism ☑ THR/WIN Operation ☑ Audio Check ☑ Battery Check (Min 4.4 VDC)

☑ F/S Response Check ☑ Meter Zeroed ☑ Reset Check HV Check (+/- 2.5%): ☑ 500 V ☑ 1000 V ☑ 1500 V

Source Distance: ☐ Contact ☑ 6 inches ☐ Other: Cable Length: ☐ 39-inch ☐ 72-inch ☑ Other: 10'

Source Geometry: ☑ Side ☐ Below ☐ Other: Temperature: 76 °F Relative Humidity 20 %

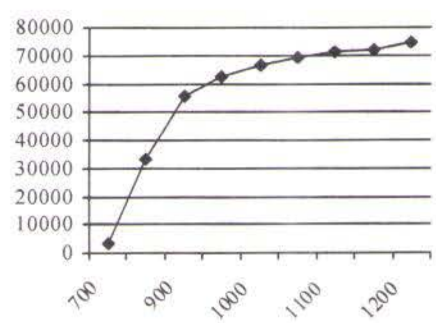
Threshold: 10 mV Window: Barometric Pressure: 24.75 inches Hg

Instrument found within tolerance: ☑ Yes ☐ No

Range/Multiplier	Reference Setting	"As Found Reading"		Meter Reading		Integrated 1-Min. Count	Log Scale Count	
x 1000	400	400	kcpm	400	kcpm	400069	400	kcpm
x 1000	100	100	kcpm	100	kcpm		100	kcpm
x 100	400	400	kcpm	400	kcpm	40007	400	kcpm
x 100	100	100	kcpm	100	kcpm		100	kcpm
x 10	400	400	kcpm	400	kcpm	4000	400	kcpm
x 10	100	100	kcpm	100	kcpm		100	kcpm
x 1	400	400	cpm	400	cpm	400	400	cpm
x 1	100	100	cpm	100	cpm		100	cpm

High Voltage	Source Counts	Background
700	3444	
800	33527	
900	55467	
950	62258	
1000	66276	
1050	69312	
1100	70960	
1150	71875	11569
1200	74556	

Voltage Plateau



Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV =1150

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ☑ 201932 Fluke multimeter serial number: ☐ 8749012

☐ Alpha Source: Th-230 @ 12,800 dpm (1/4/12) sn: 4098-03 ☑ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03

☐ Beta Source: Tc-99 @ 17,700 dpm (1/4/12) sn: 4099-03 ☐ Other Source:

Calibrated By: [signature] Calibration Date: 10-4-12 Calibration Due: 10-4-13

Reviewed By: [signature] Review Date: 10/4/12

This calibration conforms to the requirements and acceptable calibration conditions of ANSI N323A - 1997.
NMRCB Registration No. 921-3 * Calibration of Radiation Detection Instrument Devices

ERG

Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc.
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	254757
Detector:	Manufacturer:	Ludlum	Model Number:	44-10	Serial Number:	PR199131

☑ Mechanical Check ☑ Geotropism ☑ THR/WIN Operation ☑ Audio Check ☑ Battery Check (Min 4.4 VDC)

☑ F/S Response Check ☑ Meter Zeroed ☑ Reset Check HV Check (+/- 2.5%): ☑ 500 V ☑ 1000 V ☑ 1500 V

Source Distance: ☐ Contact ☑ 6 inches ☐ Other: Cable Length: ☐ 39-inch ☐ 72-inch ☑ Other: 40'

Source Geometry: ☑ Side ☐ Below ☐ Other: Temperature: 75 °F Relative Humidity 20 %

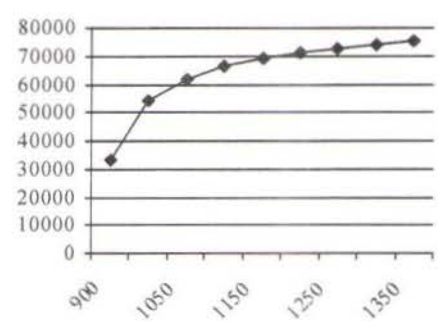
Threshold: 10 mV Window: Barometric Pressure: 24.69 inches Hg

Instrument found within tolerance: ☑ Yes ☐ No

Range/Multiplier	Reference Setting	"As Found Reading"		Meter Reading		Integrated 1-Min. Count	Log Scale Count	
x 1000	400	400	kcpm	400	kcpm	400199	400	kcpm
x 1000	100	100	kcpm	100	kcpm		100	kcpm
x 100	400	400	kcpm	400	kcpm	39973	400	kcpm
x 100	100	100	kcpm	100	kcpm		100	kcpm
x 10	400	400	kcpm	400	kcpm	3997	400	kcpm
x 10	100	100	kcpm	100	kcpm		100	kcpm
x 1	400	400	cpm	400	cpm	400	400	cpm
x 1	100	100	cpm	100	cpm		100	cpm

High Voltage	Source Counts	Background
900	33120	
1000	54416	
1050	61657	
1100	66565	
1150	69415	
1200	70947	
1250	72598	
1300	74169	11223
1350	75348	

Voltage Plateau



Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV =1300

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ☑ 201932 Fluke multimeter serial number: ☐ 8749012

☐ Alpha Source: Th-230 @ 12,800 dpm (1/4/12) sn: 4098-03 ☑ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03

☐ Beta Source: Tc-99 @ 17,700 dpm (1/4/12) sn: 4099-03 ☐ Other Source:

Calibrated By: [signature] Calibration Date: 10-4-12 Calibration Due: 10-4-13

Reviewed By: [signature] Review Date: 10/4/12

ERG

Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc.
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	254757
Detector:	Manufacturer:	Ludlum	Model Number:	44-10	Serial Number:	PR199131

☑ Mechanical Check ☑ Geotropism ☑ THR/WIN Operation ☑ Audio Check ☑ Battery Check (Min 4.4 VDC)

☑ F/S Response Check ☑ Meter Zeroed ☑ Reset Check HV Check (+/- 2.5%): ☑ 500 V ☑ 1000 V ☑ 1500 V

Source Distance: ☐ Contact ☑ 6 inches ☐ Other: Cable Length: ☑ 39-inch ☐ 72-inch ☐ Other:

Source Geometry: ☑ Side ☐ Below ☐ Other: Temperature: 75 °F Relative Humidity 20 %

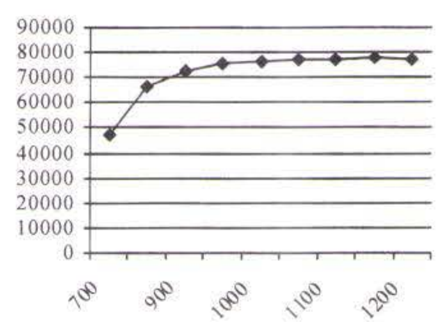
Threshold: 10 mV Window: Barometric Pressure: 24.69 inches Hg

Instrument found within tolerance: ☑ Yes ☐ No

Range/Multiplier	Reference Setting	"As Found Reading"		Meter Reading		Integrated 1-Min. Count	Log Scale Count	
x 1000	400	400	kcpm	400	kcpm	400199	400	kcpm
x 1000	100	100	kcpm	100	kcpm		100	kcpm
x 100	400	400	kcpm	400	kcpm	39973	400	kcpm
x 100	100	100	kcpm	100	kcpm		100	kcpm
x 10	400	400	kcpm	400	kcpm	3997	400	kcpm
x 10	100	100	kcpm	100	kcpm		100	kcpm
x 1	400	400	cpm	400	cpm	400	400	cpm
x 1	100	100	cpm	100	cpm		100	cpm

High Voltage	Source Counts	Background
700	47244	
800	66664	
900	72668	
950	75497	
1000	76213	
1050	77087	11824
1100	77365	
1150	77663	
1200	77364	

Voltage Plateau



Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV =1050

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ☑ 201932 Fluke multimeter serial number: ☐ 8749012

☐ Alpha Source: Th-230 @ 12,800 dpm (1/4/12) sn: 4098-03 ☑ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03

☐ Beta Source: Tc-99 @ 17,700 dpm (1/4/12) sn: 4099-03 ☐ Other Source:

Calibrated By: [signature] Calibration Date: 10-4-12 Calibration Due: 10-4-13

Reviewed By: [signature] Review Date: 10/4/12

This calibration conforms to the requirements and acceptable calibration conditions of ANSI N323A - 1997.
NMRCB Registration No. 921-3 * Calibration of Radiation Detection Instrument Devices

ERG

Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc.
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

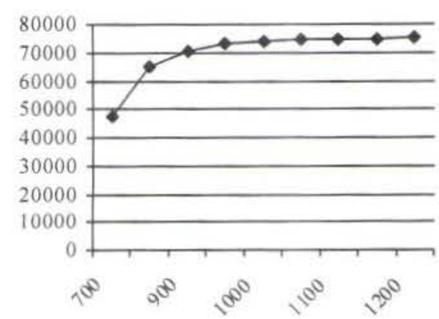
	Manufacturer:		Model Number:		Serial Number:	
Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	254772
Detector:	Manufacturer:	Ludlum	Model Number:	44-10	Serial Number:	PR118372

☑ Mechanical Check ☑ Geotropism ☑ THR/WIN Operation ☑ Audio Check ☑ Battery Check (Min 4.4 VDC)
☑ F/S Response Check ☑ Meter Zeroed ☑ Reset Check HV Check (+/- 2.5%): ☑ 500 V ☑ 1000 V ☑ 1500 V
Source Distance: ☐ Contact ☑ 6 inches ☐ Other: Cable Length: ☑ 39-inch ☐ 72-inch ☐ Other:
Source Geometry: ☑ Side ☐ Below ☐ Other: Temperature: 74 °F Relative Humidity 20 %
Threshold: 10 mV Window: Barometric Pressure: 24.69 inches Hg
Instrument found within tolerance: ☑ Yes ☐ No

Range/Multiplier	Reference Setting	"As Found Reading"		Meter Reading		Integrated 1-Min. Count	Log Scale Count	
x 1000	400	400	kcpm	400	kcpm	399755	400	kcpm
x 1000	100	100	kcpm	100	kcpm		100	kcpm
x 100	400	400	kcpm	400	kcpm	39977	400	kcpm
x 100	100	100	kcpm	100	kcpm		100	kcpm
x 10	400	400	kcpm	400	kcpm	3997	400	kcpm
x 10	100	100	kcpm	100	kcpm		100	kcpm
x 1	400	400	cpm	400	cpm	399	400	cpm
x 1	100	100	cpm	100	cpm		100	cpm

High Voltage	Source Counts	Background
700	47664	
800	65093	
900	70252	
950	73177	
1000	73714	
1050	74473	
1100	74724	11991
1150	74658	
1200	75268	

Voltage Plateau



Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV =1100

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ☑ 201932
Fluke multimeter serial number: ☐ 8749012
☐ Alpha Source: Th-230 @ 12,800 dpm (1/4/12) sn: 4098-03
☑ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03
☐ Beta Source: Tc-99 @ 17,700 dpm (1/4/12) sn: 4099-03
☐ Other Source:

Calibrated By: Calibration Date: 10-4-12 Calibration Due: 10-4-13

Reviewed By: Review Date: 10/04/12

ERG

Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc.
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

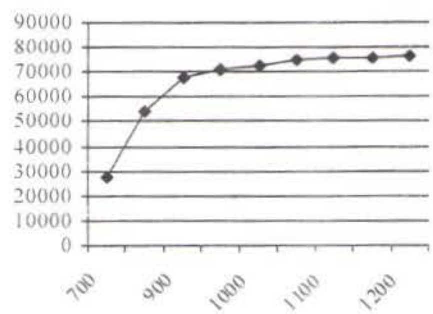
Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	262316
Detector:	Manufacturer:	Ludlum	Model Number:	44-10	Serial Number:	PR150786

✔ Mechanical Check ✔ Geotropism ✔ THR/WIN Operation ✔ Audio Check ✔ Battery Check (Min 4.4 VDC)
✔ F/S Response Check ✔ Meter Zeroed ✔ Reset Check HV Check (+/- 2.5%): ✔ 500 V ✔ 1000 V ✔ 1500 V
Source Distance: _ Contact ✔ 6 inches _ Other: Cable Length: _ 39-inch ✔ 72-inch _ Other:
Source Geometry: ✔ Side _ Below _ Other: Temperature: 74 °F Relative Humidity 20 %
Threshold: 10 mV Window: Barometric Pressure: 24.75 inches Hg
Instrument found within tolerance: ✔ Yes _ No

Range/Multiplier	Reference Setting	"As Found Reading"		Meter Reading		Integrated 1-Min. Count	Log Scale Count	
x 1000	400	400	kcpm	400	kcpm	399984	400	kcpm
x 1000	100	100	kcpm	100	kcpm		100	kcpm
x 100	400	400	kcpm	400	kcpm	39984	400	kcpm
x 100	100	100	kcpm	100	kcpm		100	kcpm
x 10	400	400	kcpm	400	kcpm	3999	400	kcpm
x 10	100	100	kcpm	100	kcpm		100	kcpm
x 1	400	400	cpm	400	cpm	400	400	cpm
x 1	100	100	cpm	100	cpm		100	cpm

High Voltage	Source Counts	Background
700	27396	
800	53789	
900	67756	
950	70677	
1000	72372	
1050	74950	
1100	75307	12301
1150	75780	
1200	76531	

Voltage Plateau



Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV =1100

Reference Instruments and/or Sources:

Ludlum pulser serial number: _ 97743 ✔ 201932
Fluke multimeter serial number: _ 8749012
_ Alpha Source: Th-230 @ 12,800 dpm (1/4/12) sn: 4098-03
✔ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03
_ Beta Source: Tc-99 @ 17,700 dpm (1/4/12) sn: 4099-03
_ Other Source:

Calibrated By: [signature] Calibration Date: 10-30-12 Calibration Due: 10-30-13

Reviewed By: [signature] Review Date: 10/30/12

ERG

Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc.
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	282982
Detector:	Manufacturer:	Ludlum	Model Number:	44-2	Serial Number:	PR248172

☑ Mechanical Check ☑ Geotropism ☑ THR/WIN Operation ☑ Audio Check ☑ Battery Check (Min 4.4 VDC)

☑ F/S Response Check ☑ Meter Zeroed ☑ Reset Check HV Check (+/- 2.5%): ☑ 500 V ☑ 1000 V ☑ 1500 V

Source Distance: ☐ Contact ☑ 6 inches ☐ Other: Cable Length: ☐ 39-inch ☐ 72-inch ☑ Other: 40'

Source Geometry: ☑ Side ☐ Below ☐ Other: Temperature: 80 °F Relative Humidity 20 %

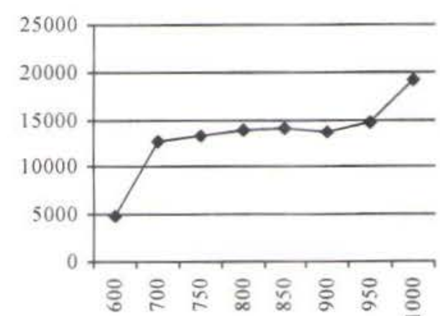
Threshold: 10 mV Window: Barometric Pressure: 24.66 inches Hg

Instrument found within tolerance: ☑ Yes ☐ No

Range/Multiplier	Reference Setting	"As Found Reading"		Meter Reading		Integrated 1-Min. Count	Log Scale Count	
x 1000	400	400	kcpm	400	kcpm	400246	400	kcpm
x 1000	100	100	kcpm	100	kcpm		100	kcpm
x 100	400	400	kcpm	400	kcpm	40031	400	kcpm
x 100	100	100	kcpm	100	kcpm		100	kcpm
x 10	400	400	kcpm	400	kcpm	4004	400	kcpm
x 10	100	100	kcpm	100	kcpm		100	kcpm
x 1	400	400	cpm	400	cpm	401	400	cpm
x 1	100	100	cpm	100	cpm		100	cpm

High Voltage	Source Counts	Background
600	4897	
700	12637	
750	13338	
800	13930	
850	14126	2420
900	13805	
950	14728	
1000	19123	

Voltage Plateau



Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV =850

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ☑ 201932 Fluke multimeter serial number: ☐ 8749012

☐ Alpha Source: Th-230 @ 12,800 dpm (1/4/12) sn: 4098-03 ☑ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03

☐ Beta Source: Tc-99 @ 17,700 dpm (1/4/12) sn: 4099-03 ☐ Other Source:

Calibrated By: [signature] Calibration Date: 10-4-12 Calibration Due: 10-4-13

Reviewed By: [signature] Review Date: 10/4/12

This calibration conforms to the requirements and acceptable calibration conditions of ANSI N323A - 1997.
NMRCB Registration No. 921-3 * Calibration of Radiation Detection Instrument Devices

Reuter-Stokes

Calibration Certificate

Reuter-Stokes certifies that the Environmental Radiation Monitor, identified below, has been calibrated for output using the shadow shield technique*, and calibrated with radiation sources traceable to the National Institute of Standards and Technology.

Sensor Type:	100 R/Hr
Serial Number:	07J00KM1
Calibration Date:	7/23/12
Sensitivity:	10.1 mV/μR/h

Authorized Signature

*Calibration Procedure: RS-SOP 238.1

Reuter-Stokes

Calibration Data

Sensor Type:	100 R/Hr	Source (CS-137):	BB-400
Serial Number:	07J00KM1	Date of Certification:	12/1/94
Calibration Date:	7/23/12	Exposure Rate at 1 meter:	4.226 mR/h

Customer Name: RADIATION SAFETY AND CONTROL

Sensitivity (Ra-226): 10.1 mV/μR/h

Distance		Exposure Rate	P+S+A	S+A	P	k(CS-137)
Feet	cm	μR/h	V	V	V	mV/μR/h
11.8	359	213.844	2.753	0.565	2.187	10.23
13.8	420	155.666	2.091	0.500	1.590	10.22
15.8	481	118.238	1.658	0.452	1.206	10.20
17.8	542	92.762	1.368	0.421	0.947	10.21

k(CS-137) = 10.21 mv/μR/h

$\bar{k}$ = 10.21 mv/μR/h

k(Ra-226) = .9892 k(CS-137)

σ = .011 mv/μR/h

k(Ra-226) = 10.1 mv/μR/h

$V = \frac{\sigma}{k} =$ 0.105%

By: RL

Date: 7/23/12

Reuter-Stokes

RSS-131 FIRMWARE PARAMETERS

S/N 07J00KM1

RAC	2.187E-08
ZLN	0.000E-00
ZMN	4.324E-01
ZHN	-2.127E-03
ZLD	0.000E-00
ZMD	-2.414E-04
ZHD	-6.174E-07
RLN	4.619E+11
RMN	2.231E+09
RHN	1.001E+07
RLV	-1.524E+08
RMV	2.094E+04
RHV	-1.548E+02

Only change in constants is
In the RAC from 2.210E-08

By: ______________________
Level 2 Nuclear / Electrical Inspector

Date: 7/23/12

Reviewed By: ______________________
Product Engineer

Appendix C

Static Measurements

Static Gamma Measurement Form

Date 9-13-12

(1) Ratemeter: Ludlum 2221 Serial No. 254772 Cal. Due Date 8-31-13

(1) Detector: Ludlum 4470 Serial No. PR118372 Cal. Due Date: 8-31-13

Technician NW

Location ID	Detector Response (cpm)		Comments
	Bare	Collimated	
231	n/a	n/a	Location is in sidewall (mesa)
229	22130	6392	
228	21710	5718	
226	20546	5577	
224	19307	5336	
222	n/a	n/a	Location is in mesa wall
221	22935	5948	
219	20165	5107	
217	20278	5387	
215	21921	6490	
213	30861	6750	
211	26230	6372	
209	22035	5702	
207	19500	5195	

Static Gamma Measurement Form

Date 9-13-12

(1) Ratemeter: Ludlum 2221 Serial No. 254772 Cal. Due Date 8-31-13

(1) Detector: Ludlum 44-10 Serial No. PR118372 Cal. Due Date: 8-31-13

Technician NW

Location ID	Detector Response (cpm)		Comments
	Bare	Collimated	
206	n/a	n/a	Location is in sidewall (mesa)
204	189148	89811	
202	29865	6348	
200	24291	6067	
198	23030	5841	
196	n/a	n/a	Location is in sidewall (mesa)
195	51087	10484	
193	99578	24840	
191	33897	6390	
189	26032	5708	
187	24759	6046	
185	120479	32386	
183	226525	62854	
181	94010	24321	

Static Gamma Measurement Form

Date 9-13-12

(1) Ratemeter: Ludlum 2221 Serial No. 254772 Cal. Due Date 8-31-13

(1) Detector: Ludlum 44-10 Serial No. PR118372 Cal. Due Date: 8-31-13

Technician NW

Location ID	Detector Response (cpm)		Comments
	Bare	Collimated	
179	78259	23746	
177	68164	23196	
175	43373	7331	
173	254987	77208	
171	193911	63885	
169	79551	20621	
167	83675	23485	
165	28088	5012	on mesa bench
163	214980	75777	
161	241121	82764	
159	52406	9613	
157	42606	8917	
155	26890	6118	
154	n/a	n/a	in mesa wall

Static Gamma Measurement Form

Date 9-13-12

(1) Ratemeter: Ludlum 2221 Serial No. 254772 Cal. Due Date 8-31-13

(1) Detector: Ludlum 44-10 Serial No. PR118372 Cal. Due Date: 8-31-13

Technician NW

Location ID	Detector Response (cpm)		Comments
	Bare	Collimated	
152	156308	41894	
150	147657	47394	
148	63293	19574	
146	81611	17263	
144	220217	59467	
142	60128	9256	
140	37786	7606	
138	128390	36619	
136	481245	174822	
134	69822	16300	
132	36951	6689	
130	153300	37092	
128	392024	131199	
126	191641	69159 ~~6958~~ NV	

Static Gamma Measurement Form

Date 9-13-12

(1) Ratemeter: Ludlum 2221 Serial No. 254772 Cal. Due Date 8-31-13

(1) Detector: Ludlum 44-10 Serial No. PR118372 Cal. Due Date: 8-31-13

Technician NW

Location ID	Detector Response (cpm)		Comments
	Bare	Collimated	
124	33669	6611	
123	267388	77131	
121	274578	72021	
119	342398	120395	
117	57826	13931	
114	286548	117800	
112	246263	74578	
110	67463	11953	
108	33186	5780	
105	138928	33415	
103	140388	36269	
101	146945	39624	
99	77435	22425	
97	27207	5156	

Static Gamma Measurement Form

Date 9-13-12

① Ratemeter: Ludlum 2221 Serial No. 254772 Cal. Due Date 8-31-13

① Detector: Ludlum 44-10 Serial No. PR118372 Cal. Due Date: 8-31-13

Technician NW

Location ID	Detector Response (cpm)		Comments
	Bare	Collimated	
96	170705	49216	
94	256667	93489	
92	162480	50856	
90	71193	12674	
88	26637	4853	toe of mesa
85	158184	46861	
83	210332	73207	
81	167691	53732	
79	34216	6454	
77	82422	20335	
75	162661	47447	
73	244782	106454	
71	116259	32070	
70	49999	9256	

Static Gamma Measurement Form

Date 9-13-12

Ratemeter: Ludlum 2221 Serial No. 254772 Cal. Due Date 8-31-13

Detector: Ludlum 44-10 Serial No. PR118372 Cal. Due Date: 8-31-13

Technician NW

Location ID	Detector Response (cpm)		Comments
	Bare	Collimated	
67	106297	29525	
65	117234	37121	
63	150460	45204	
61	89125	21224	
59	35752	6517	
57	55828	16616	
55	45060	15253	
53	31902	9067	
51	27711	6399	
49	106522	28748	
47	128253	41149	
45	136338	49851	
43	108818	33126	
41	43367	10549	

Static Gamma Measurement Form

Date 9-13-12

① Ratemeter: Ludlum 2221 Serial No. 254772 Cal. Due Date 8-31-13

① Detector: Ludlum 44-10 Serial No. PR118372 Cal. Due Date: 8-31-13

Technician NW

Location ID	Detector Response (cpm)		Comments
	Bare	Collimated	
39	27351	5962	
37	28883	5977	
35	20714	4667	
32	72163	21859	
30	130 011	39795	
28	179283	52672 ~~56672~~ NW	
26	70314	13591	
24	55174	13353	
22	45242	10330	
20	22145	5292	
18	30748	8494	
17	39944	6590	
15	136777	40626	
13	76180	19735	

Static Gamma Measurement Form

Date 9-13-12

① Ratemeter: Ludlum 2221 Serial No. 254772 Cal. Due Date 8-31-13

① Detector: Ludlum 44-10 Serial No. PR118372 Cal. Due Date: 8-31-13

Technician MW

Location ID	Detector Response (cpm)		Comments
	Bare	Collimated	
11	73742	22718	
9	45004	9800	
7	31792	7464	
6	58909	9257	
4	67303	17824	
2	50880	14350	

Static Gamma Measurement Form

Date 9-13-12

(2) Ratemeter: Ludlum 2221 Serial No. ~~254772~~ 254757 NW Cal. Due Date ~~8-31-13~~ 4-30-13 NW

(2) Detector: Ludlum 44-10 Serial No. ~~PR118372~~ PR199131 NW Cal. Due Date: ~~8-31-13~~ 4-30-13 NW

Technician NW

Location ID	Detector Response (cpm)		Comments
	Bare	Collimated	
230	21325	5403	
229	20458	4789	
227	21457	4986	
225	22202	5534	
223	18010	4495	
220	17955	3974	
218	19598	4587	
216	19881	5142	
214	35297	6419	
212	27847	5512	
210	21796	4798	
208	20877	4714	
205	46839	7304	
203	346919	124106	

Static Gamma Measurement Form

Date 9-13-12

② Ratemeter: Ludlum 2221 Serial No. 254757 Cal. Due Date 4-30-13

② Detector: Ludlum 4470 Serial No. PR199131 Cal. Due Date: 4-30-13

Technician

Location ID	Detector Response (cpm)		Comments
	Bare	Collimated	
201	27008	5241	
199	22660	4771	
197	21252	4843	
194	102251	18702	
192	60233	11508	
190	29625	5390	
188	25406	5145	
186	37686	6574	
184	119115	29040	
182	121376	35588	
180	93959	25549	
178	125628	39506	
176	27645	4546	
174	198265	45975	

Static Gamma Measurement Form

Date 9-13-12

(2) Ratemeter: Ludlum 2221 Serial No. 254757 Cal. Due Date 4-30-13

Detector: Ludlum 44-10 Serial No. PR199131 Cal. Due Date: 4-30-13

Technician NW

Location ID	Detector Response (cpm)		Comments
	Bare	Collimated	
172	318064	104726	
170	111546	27213	
168	87419	25163	
166	82091	26665	
164	33514	4673	
162	165875	49021	
160	170202	74359	
158	47925	9761	
156	34699	6759	
153	222779	69811	
151	222717	66463	
149	122123	33143	
147	35229	6163	
145	141696	27240	

Static Gamma Measurement Form

Date 9-13-12

Ratemeter: Ludlum 2221 Serial No. 254757 Cal. Due Date 4-30-13

Detector: Ludlum 44-10 Serial No. PR199131 Cal. Due Date: 4-30-13

Technician NW

Location ID	Detector Response (cpm)		Comments
	Bare	Collimated	
143	230780	62403	
141	55557	11778	
139	29770	5753	
137	258750	77773	
135	99157	18512	
133	81710	18491	
131	269978	78749	
129	608831	193257	
127	74839	9957	
125	45837	8022	
122	185871	38101	
120	347358	101854	
118	108514	26639	
116	32473	5445	toe of mesa

Static Gamma Measurement Form

Date 9-13-12

Ratemeter: Ludlum 2221 Serial No. 254757 Cal. Due Date 4-30-13

Detector: Ludlum 44-10 Serial No. PR199131 Cal. Due Date: 4-30-13

Technician NW

Location ID	Detector Response (cpm)		Comments
	Bare	Collimated	
115	186304	48719	
113	209074	67279	
111	180259	51657	
109	39805	5059	
107	30892	5156	
106	110388	21015	
104	359663	109978	
102	179573	48327	
100	85327	13852	
98	28044	4626	
95	196753	61720	
93	186282	47531	
91	139904	35242	
89	45379	7453	

Static Gamma Measurement Form

Date 9-13-12

Ratemeter: Ludlum 2221 Serial No. 254757 Cal. Due Date 4-30-13

Detector: Ludlum 44-10 Serial No. PR199131 Cal. Due Date: 4-30-13

Technician NW

Location ID	Detector Response (cpm)		Comments
	Bare	Collimated	
86	192257	58084	
84	146839	39187	
82	143755	36973	
80	47403	7085	
78	24017	4015	
76	146293	43713	
74	128894	31101	
72	113126	27664	
69	74855	20185	
68	33583	7127	
66	119702	29862	
64	147069	42027	
62	142575	43535	
60	40525	6311	

Static Gamma Measurement Form

Date 9-13-12

Ratemeter: Ludlum 2221 Serial No. 254757 Cal. Due Date 4-30-13

Detector: Ludlum 44-10 Serial No. PR199131 Cal. Due Date: 4-30-13

Technician mw

Location ID	Detector Response (cpm)		Comments
	Bare	Collimated	
58	32775	5915	
56	31695	6782	
54	28905	6262	
52	28372	6616	
50	94107	22456	
48	96159	23106	
46	75450	13177	
44	125485	35482	
42	141357	41670	
40	28683	4758	
38	45440	10655	
36	25493	5305	
34	23365	5067	
33	101508	26859	

Static Gamma Measurement Form

Date 9-13-12

(2) Ratemeter: Ludlum 2221 Serial No. 254757 Cal. Due Date 4-30-13

Detector: Ludlum 44-10 Serial No. PR199131 Cal. Due Date: 4-30-13

Technician NW

Location ID	Detector Response (cpm)		Comments
	Bare	Collimated	
31	53526	10298	
29	148322	47986	
27	169741	61687	
25	90665	33037	
23	51615	13252	
21	25557	4637	
19	22111	4538	
16	68350	16176	
14	116960	35284	
12	38668	6309	
10	33503	5642	
8	43628	9154	
5	78162	17858	
3	48401	10789	

Static Gamma Measurement Form

Date 9-13-12

Ratemeter: Ludlum 2221 Serial No. 254757 Cal. Due Date 4-30-13

Detector: Ludlum 44-10 Serial No. PR199131 Cal. Due Date: 4-30-13

Technician NW

Location ID	Detector Response (cpm)		Comments
	Bare	Collimated	
1	69072	16882	

Appendix D

Geoposition of Static Measurements

Geopositions of Static Measurement Locations in Area A

Location ID	Easting (ft)[a]	Norting (ft)[a]	Location ID	Easting (ft)[a]	Norting (ft)[a]	Location ID	Easting (ft)[a]	Norting (ft)[a]
1	2756060	1586500	42	2755930	1586690	83	2755670	1586890
2	2756000	1586500	43	2755860	1586700	84	2755600	1586890
3	2755930	1586500	44	2755800	1586700	85	2755540	1586890
4	2755870	1586500	45	2755730	1586700	86	2755470	1586890
5	2755800	1586500	46	2755670	1586700	87	2755410	1586890
6	2755730	1586500	47	2755600	1586700	88	2755930	1586960
7	2756260	1586560	48	2755540	1586700	89	2755870	1586960
8	2756190	1586570	49	2755470	1586700	90	2755800	1586960
9	2756130	1586570	50	2755400	1586700	91	2755730	1586960
10	2756060	1586560	51	2756460	1586760	92	2755670	1586960
11	2756000	1586570	52	2756390	1586760	93	2755600	1586960
12	2755930	1586560	53	2756320	1586760	94	2755540	1586960
13	2755870	1586560	54	2756260	1586760	95	2755470	1586960
14	2755800	1586560	55	2756190	1586760	96	2755410	1586960
15	2755740	1586560	56	2756130	1586760	97	2755990	1587020
16	2755670	1586560	57	2756060	1586760	98	2755930	1587020
17	2755600	1586570	58	2756000	1586760	99	2755870	1587020
18	2756460	1586630	59	2755930	1586760	100	2755800	1587020
19	2756390	1586630	60	2755870	1586760	101	2755730	1587020
20	2756330	1586630	61	2755800	1586760	102	2755670	1587020
21	2756260	1586630	62	2755730	1586760	103	2755600	1587020
22	2756190	1586630	63	2755670	1586760	104	2755540	1587020
23	2756130	1586630	64	2755600	1586760	105	2755470	1587020
24	2756060	1586630	65	2755540	1586760	106	2755410	1587020
25	2756000	1586630	66	2755470	1586760	107	2756000	1587090
26	2755930	1586630	67	2755410	1586760	108	2755930	1587090
27	2755870	1586630	68	2756000	1586830	109	2755870	1587090
28	2755800	1586630	69	2755930	1586830	110	2755800	1587090
29	2755730	1586630	70	2755870	1586830	111	2755730	1587090
30	2755670	1586630	71	2755800	1586830	112	2755670	1587090
31	2755600	1586630	72	2755730	1586830	113	2755600	1587090
32	2755540	1586630	73	2755670	1586830	114	2755540	1587090
33	2755470	1586630	74	2755600	1586830	115	2755470	1587090
34	2756450	1586700	75	2755540	1586830	116	2756000	1587160
35	2756390	1586700	76	2755470	1586830	117	2755930	1587160
36	2756320	1586700	77	2755400	1586830	118	2755870	1587150
37	2756260	1586700	78	2756000	1586890	119	2755800	1587150
38	2756190	1586700	79	2755930	1586890	120	2755730	1587150
39	2756130	1586700	80	2755870	1586890	121	2755670	1587160
40	2756060	1586700	81	2755800	1586890	122	2755600	1587160
41	2756000	1586700	82	2755730	1586890	123	2755540	1587160

Geopositions of Static Measurement Locations in Area A (continued)

Location ID	Easting (ft)[a]	Northing (ft)[a]
124	2756000	1587220
125	2755930	1587220
126	2755860	1587220
127	2755800	1587220
128	2755730	1587220
129	2755670	1587220
130	2755600	1587220
131	2755540	1587220
132	2756000	1587290
133	2755930	1587290
134	2755870	1587290
135	2755800	1587290
136	2755730	1587290
137	2755670	1587290
138	2755600	1587290
139	2756060	1587350
140	2756000	1587350
141	2755930	1587350
142	2755870	1587350
143	2755800	1587350
144	2755740	1587350
145	2755670	1587350
146	2755600	1587350
147	2756060	1587420
148	2756000	1587420
149	2755930	1587420
150	2755870	1587420
151	2755800	1587420
152	2755730	1587420
153	2755670	1587420
154	2755600	1587420
155	2756190	1587480
156	2756130	1587480
157	2756060	1587480
158	2756000	1587480
159	2755930	1587480
160	2755860	1587480
161	2755800	1587480
162	2755730	1587480
163	2755670	1587480
164	2755600	1587480
165	2755540	1587480
166	2756190	1587550
167	2756130	1587550
168	2756060	1587550
169	2756000	1587550
170	2755930	1587550
171	2755860	1587550
172	2755800	1587550
173	2755730	1587550
174	2755670	1587550
175	2755600	1587550
176	2755540	1587550
177	2756190	1587610
178	2756130	1587610
179	2756060	1587610
180	2756000	1587610
181	2755930	1587610
182	2755870	1587610
183	2755800	1587610
184	2755730	1587610
185	2755670	1587610
186	2755600	1587610
187	2756260	1587680
188	2756190	1587680
189	2756130	1587680
190	2756060	1587680
191	2756000	1587680
192	2755930	1587680
193	2755870	1587680
194	2755800	1587680
195	2755730	1587680
196	2755670	1587680
197	2756320	1587740
198	2756260	1587750
199	2756190	1587740
200	2756130	1587750
201	2756060	1587740
202	2756000	1587750
203	2755930	1587750
204	2755870	1587750
205	2755800	1587740
206	2755730	1587740
207	2756320	1587810
208	2756260	1587810
209	2756190	1587810
210	2756130	1587810
211	2756060	1587810
212	2756000	1587810
213	2755930	1587810
214	2755870	1587810
215	2756460	1587880
216	2756390	1587880
217	2756320	1587880
218	2756260	1587880
219	2756190	1587870
220	2756130	1587880
221	2756060	1587880
222	2756000	1587880
223	2756520	1587940
224	2756460	1587940
225	2756390	1587940
226	2756320	1587940
227	2756260	1587940
228	2756190	1587940
228	2756190	1587940
229	2756130	1587940
230	2756260	1588010
231	2756190	1588010

Notes:
[a]Coordinate system in NAD 1983, New Mexico West

Appendix E

Down-hole Gamma Measurements

Table E-1. Down-hole Gamma Measurements in Background Reference Area

Detector	2-in. by 2-in. with 10-ft Cable		1-in. by 1-in. with 40-ft Cable	
Depth Interval (cm)	0-15	15-30	0-15	15-30
Boring Location	Count Rate (c min^{-1})			
BRA-01	16306	17778	3361	3972
BRA-02	15681	17540	3266	3486
BRA-03	21373	23306	4623	5256
BRA-04	15766	18073	3577	4544
BRA-05	15956	20229	4164	4240
BRA-06	17045	18412	3583	4065
BRA-07	16635	20075	3989	4722
BRA-08	18151	22445	3893	4168
BRA-09	19801	22222	4712	4818
BRA-10	17643	19529	3935	4271
BRA-11	15709	17108	3366	4044
BRA-12	15707	19641	3471	4061
BRA-13	16412	20290	3888	4750
BRA-14	15870	20101	3797	4247
BRA-15	15070	16818	3272	3681

Notes:
c min^{-1} = counts per minute
cm = centimeter
ft = foot
in. = inch

Table E-2. Down-hole Gamma Measurements in Area A

Boring Location	Depth Interval (cm)	Down-hole Gamma Count Rate ($c\ min^{-1}$)[a]
AA-01	Ground Surface	71835
	0 - 24	89491
	24 - 54	9060
	54 - 84	5196
	84 - 114	7517
	114 - 144	3310
	144 - 174	2894
	174 - 204	3301
	204 - 234	3150
AA-02	Ground Surface	18312
	0 - 15	19984
	15 - 30	22323
AA-03	Ground Surface	52778
	0 - 24	307397
	24 - 54	236960
	54 - 84	14944
	84 - 114	8980
	114 - 144	8269
	144 - 174	6896
	174 - 204	5795
	204 - 234	6262
AA-04	Ground Surface	42214
	0 - 24	67906
	24 - 54	43324
	54 - 84	43867
	84 - 114	40946
	114 - 144	18278
	144 - 174	18153
	174 - 204	39290
	204 - 234	28266
	234 - 264	8375
	264 - 294	5184
	294 - 324	5039
	324 - 354	3713
	354 - 384	3734
	384 - 414	3750
	414 - 444	4133
	444 - 474	5561

Table E-2. Down-hole Gamma Measurements in Area A (continued)

Boring Location	Depth Interval (cm)	Down-hole Gamma Count Rate (c min^{-1})[a]
AA-04 (continued)	474 - 504	5014
	504 - 534	4931
	534 - 564	5199
	564 - 594	4406
	594 - 624	5448
	624 - 654	6003
	654 - 684	4932
	684 - 714	4318
	714 - 744	5642
	744 - 774	5331
	774 - 804	6111
	804 - 834	6556
	834 - 864	5866
	864 - 894	6691
	894 - 924	6216
	924 - 954	5071
AA-05	Ground Surface	3946
	0 - 24	3475
	24 - 54	2612
	54 - 84	2220
	84 - 114	1909
	114 - 144	2176
AA-06	Ground Surface	18796
	0 - 24	37449
	24 - 54	31162
	54 - 84	24408
	84 - 114	27179
	114 - 144	31351
	144 - 174	36025
	174 - 204	78750
	204 - 234	376301
	234 - 264	112189
	264 - 294	16612
	294 – 324[b]	14333

Table E-2. Down-hole Gamma Measurements in Area A (continued)

Boring Location	Depth Interval (cm)	Down-hole Gamma Count Rate (c min^{-1})[a]
AA-07	Ground Surface	27773
	0 - 24	95419
	24 - 54	174733
	54 - 84	245001
	84 - 114	210712
	114 - 144	198251
	144 - 174	174337
	174 - 204	180065
	204 - 234	167827
	234 - 264	254538
	264 - 294	650452
	294 - 324	709585
	324 - 354	120977
	354 - 384	24773
	384 - 414	15795
	414 - 444	8802
	444 - 474	10374
	474 - 504	7172
	504 – 534[c]	16252
AA-08	Ground Surface	26355
	0 - 24	63643
	24 - 54	73163
	54 - 84	74853
	84 - 114	80137
	114 - 144	76383
	144 - 174	75178
	174 - 204	81555
	204 - 234	94848
	234 - 264	105484
	264 - 294	142292
	294 - 324	274835
	324 - 354	612707
	354 - 384	469210
	384 - 414	424134
	414 - 444	421454
	474 - 504	336457
	504 - 534	61278
	534 - 564	9135

Table E-2. Down-hole Gamma Measurements in Area A (continued)

Boring Location	Depth Interval (cm)	Down-hole Gamma Count Rate (c min^{-1})[a]
AA-08 (continued)	564 - 594	7258
	594 - 624	5007
	624 - 654	4307
	654 - 684	6650
	684 - 714	5793
AA-09	Ground Surface	47199
	0 - 24	102657
	24 - 54	120926
	54 - 84	139535
	84 - 114	206132
	114 - 144	163324
	144 - 174	159056
	174 - 204	161285
	204 - 234	179136
	234 - 264	215396
	264 - 294	233656
	294 - 324	230216
	324 - 354	203616
	354 - 384	195858
	384 - 414	188384
	414 - 444	188778
	444 - 474	255970
	474 - 504	547318
	504 - 534	548734
	534 - 564	106120
	564 - 594	29534
	594 - 624	38421
	624 - 654	26903
	654 - 684	20163
	684 – 714[d]	20641
AA-10	Ground Surface	33387
	0 - 24	126437
	24 - 54	174701
	54 - 84	253157
	84 - 114	224407
	114 - 144	230771
	144 - 174	242107
	174 - 204	235442

Table E-2. Down-hole Gamma Measurements in Area A (concluded)

Boring Location	Depth Interval (cm)	Down-hole Gamma Count Rate (c min^{-1})[a]
AA-10 (continued)	204 - 234	229439
	234 - 264	214850
	264 - 294	71327
	294 - 324	37807
	324 - 354	10806
	354 - 384	13688
	384 - 414	6775
	414 - 444	4625
	444 - 474	4156
AA-11	Ground Surface	10762
	0 - 24	54270
	24 - 54	69876
	54 - 84	33425
	84 - 114	9567
	114 - 144	6322
	144 - 174	5748
	174 - 204	4883
	204 - 234	4706
AA-12	Ground Surface	85172
	0 - 24	192018
	24 - 54	22100
	54 - 84	9440
	84 - 114	9108
	114 - 144	7302
	144 - 174	6235
	174 - 204	7434
	204 - 234	7038

Notes:
[a]All count rates measured using a 1-in. by 1-in sodium iodide detector with a 40-ft cable (Ludlum 44-2/2221 serial numbers 282982/PR248172), with the exception of Boring AA-02. Measurements in AA-02 made using a 2-in. by 2-in. sodium iodide detector with a 10-ft cable (Ludlum 44-10/2221 serial numbers 117357/PR144055).
[b]Approximate depth of refusal
[c]Maximum depth of PVC pipe
[d]Base of 20 ft of PVC. Boring advanced an additional 4 ft, which was not gamma-logged.

c min^{-1} = counts per minute
cm = centimeter

Table E-3. Down-hole Gamma Measurements in Area B

Boring Location	Depth Interval (cm)	Down-hole Gamma Count Rate (c min^{-1})[a]
AB-01	Ground Surface	17468
	0 - 15	12708
	15 -30	13953
AB-02	Ground Surface	22246
	0 - 15	NR
	15 - 30	NR
AB-03	Ground Surface	12361
	0 - 15	12967
	15 -30	14207
AB-04	Ground Surface	15417
	0 - 15	16552
	15 - 30	20108
AB-05	Ground Surface	12906
	0 - 15	16865
	15 -30	21117

Notes:
[a]All count rates measured using a 2-in. by 2-in. sodium iodide detector with a 10-ft cable (Ludlum 44-10/2221 serial numbers 117357/PR144055).
NR = not recorded

c min^{-1} = counts per minute
cm = centimeter

Table E-4. Down-hole Gamma Measurements in Area C

Boring Location	Depth Interval (cm)	Down-hole Gamma Count Rate (c min^{-1})[a]
AC-01	Ground Surface	74199
	0-15	72115
	15-30	34426
	30-45	23737
	45-60	23239
AC-02	Ground Surface	105866
	0-15	101861
	15-30	48114
	30-45	29827
	45-60	24435
	60 -75	23387
AC-03	Ground Surface	33546
	0-15	28084
	15-30	23370
	30-45	23578
AC-04	Ground Surface	40736
	0-15	35285
	15-30	28200
	30-45	22033
	45-60	20190
AC-05	Ground Surface	48100
	0-15	70356
	15-30	39347
	30-45	22895
	45-60	19320
AC-06	Ground Surface	6642
	0 - 24	13507
	24 - 54	19518
	54 - 84	25293
	84 - 114	22182
	114 - 144	8358
	144 – 174[b]	6232

Table E-4. Down-hole Gamma Measurements in Area C (continued)

Boring Location	Depth Interval (cm)	Down-hole Gamma Count Rate (c min^{-1})[a]
AC-07	Ground Surface	115173
	0-15	508776
	15-30	926103
	30-45	400742
	45-60	104165
	60 -75	45154
	75-90	31106
	90-105	26145
	105-120	23168
	120-135	23643
AC-08	Ground Surface	263747
	0-15	188763
	15-30	77100
	30-45	39865
	45-60	31173
	60 -75	27090
	75-90	27406
AC-09	Ground Surface	32700
	0-15	21842
	15-30	19180
	30-45	16963
AC-10	Ground Surface	224245
	0-15	255899
	15-30	98430
	30-45	47140
	45-60	32026
	60 -75	28832
	75-90	26059
	90-105	24120
	105-120	24756
AC-11	Ground Surface	30801
	0-15	49127
	15-30	49834
	30-45	42417
	45-60	23584
	60 -75	17368

Table E-4. Down-hole Gamma Measurements in Area C (continued)

Boring Location	Depth Interval (cm)	Down-hole Gamma Count Rate ($c\ min^{-1}$)[a]
AC-12	Ground Surface	22346
	0-15	32576
	15-30	23967
	30-45	22863
AC-13	Ground Surface	55916
	0-15	41143
	15-30	28964
	30-45	24538
	45-60	21969
AC-14	Ground Surface	40892
	0-15	40014
	15-30	28874
	30-45	21831
	45-60	17366
AC-15	Ground Surface	109220
	0-15	405889
	15-30	469064
	30-45	305463
	45-60	116996
	60 -75	54585
	75-90	39981
	90-105	29479
	105-120	28913
	120-135	28156
AC-16	Ground Surface	23760
	0 - 24	30805
	24 - 54	6073
	54 - 84	5460
AC-17	Ground Surface	130637
	0-15	428391
	15-30	677860
	30-45	412426
	45-60	145424
	60 -75	58425
	75-90	39825
	90-105	32863
	105-120	29432
	120-135	28322

Table E-4. Down-hole Gamma Measurements in Area C (concluded)

Boring Location	Depth Interval (cm)	Down-hole Gamma Count Rate ($c\ min^{-1}$)[a]
AC-18	Ground Surface	19980
	0-15	21500
	15-30	22912
	30-45	22240
AC-19	Ground Surface	120399
	0-15	112372
	15-30	50238
	30-45	23499
	45-60	22062
	60 -75	22888
AC-20	Ground Surface	38973
	0-15	68638
	15-30	45554
	30-45	30478
	45-60	24184
	60 -75	21074
AC-21	Ground Surface	49693
	0-15	100319
	15-30	74642
	30-45	40839
	45-60	22940
	60 -75	20025
AC-22	Ground Surface	30487
	0-15	37495
	15-30	23377
	30-45	20112
AC-23	Ground Surface	41712
	0-15	33274
	15-30	25123

Notes:
[a]All count rates measured using a 2-in. by 2-in sodium iodide detector with a 10-ft cable (Ludlum 44-10/2221 serial numbers 117357/PR144055), with the exception of Borings AC-06 and AC-16. Measurements in AC-06 and AC-16 made using a 1-in. by 1-in. sodium iodide detector with a 40-ft cable (Ludlum 44-2/2221 serial numbers 282982/PR248172).
[b]Approximate depth of refusal

$c\ min^{-1}$ = counts per minute
cm = centimeter

Appendix F

Geotecchnical Logs

Alan Kuhn Associates LLC

BORING LOG

Boring #	**AA-01**
Sheet 1 of 1	

Project Name	**Johnny M. Mine Site**	Date	Started 10/15/12	Groundwater encountered:	Date / Time / Depth: Not Encountered
Project Number	**JM-1**		Completed 10/15/12		
Location	**Section 18, McKinley Co, NM**		Backfilled 10/15/12		
Surface Elevation	7082.4		Backfill = bentonite chips	Logged by:	**Ed Loescher**

Drilling Rig: GEOPROBE 6620DT

Driller: Louis Trujillo

Drilling Method: Direct Push

Depth, feet	Graphic Log	Sample No.	Sample Type	SPT Blow Count	Moisture Content	Dry Density (pcf)	Liquid Limit	Plasticity Index	Percent -#200	Rock: % Recovery	RQD	Fractures/ft	Weathering	Strength	Description
0															**0-1.5' Silty Sand (SM)** - Fine, Silty Sand with crushed rock fragments, trace building debris (wood, concrete, metal), greyish brown, occasional dark brown sandy clay seams, dry, loose. (Waste Rock)
															1.5 - 2.5' Sandy Clay (CL) Sandy Lean Clay, Dark brown, Dry- (Qal)
5															**2.5 -8.0' Fine Sand (SP-SM)** -Fine sand, Some silt, Tan/Light brown, Dry, Medium dense, Slight cementation. (Qal)
															End of probe = 8' below ground surface
10															
15															
20															
25															
30															

Notes: 1. drill rig hit concrete slab on first two attempts at 4-6 inches below grade. Relocated about 20' west of original location. 2. density of inplace soils estimated based on Geoprobe observations.

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BORING LOG

Boring #	AA-03
Sheet 1 of 1	

Project Name	Johnny M. Mine Site	Started	10/15/12
Project Number	JM-1	Completed	10/15/12
Location	Section 18, McKinley Co, NM	Backfilled	10/15/12
Surface Elevation	7080.42	Backfill = bentonite chips	

Groundwater encountered:	Date	Time	Depth
	Not Encountered		
Logged by:	Ed Loescher		

Drilling Rig: GEOPROBE 6620DT

Driller: Louis Trujillo

Drilling Method: Direct Push

Depth, feet	Graphic Log	Sample No.	Sample Type	SPT Blow Count	Moisture Content	Dry Density (pcf)	Liquid Limit	Plasticity Index	Percent -#200	Rock: % Recovery	Rock: RQD	Rock: Fractures/ft	Rock: Weathering	Rock: Strength	Description
0															**0-3' Silty Sand (SM)** Fine, Silty Sand with crushed rock fragments, Trace building debris (wood, concrete, metal), Greyish brown, Occasional dark brown sandy clay seams, Dry, Loose. (Waste Rock)
5															**3' - 8.0' Fine Sand (SP-SM)** -Fine sand, Some silt, Yellowish Tan, Dry, Medium dense, Slight cementation. (Qal)
10															End of probe = 8' below ground surface
15															
20															
25															
30															Notes: 1. density of inplace soils estimated based on Geoprobe observations.

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BORING LOG

Boring # **AA-06**

Sheet 1 of 1

Project Name	**Johnny M. Mine Site**	Date: Started	10/16/12	Groundwater encountered:	Date / Time / Depth: Not Encountered
Project Number	**JM-1**	Completed	10/16/12		
Location	**Section 18, McKinley Co, NM**	Backfilled	10/16/12		
Surface Elevation	7072.05	Backfill = bentonite chips		Logged by:	**Ed Loescher**

Drilling Rig: GEOPROBE 6620DT

Driller: Louis Trujillo

Drilling Method: Direct Push

Depth, feet	Graphic Log	Sample No.	Sample Type	SPT Blow Count	Moisture Content	Dry Density (pcf)	Liquid Limit	Plasticity Index	Percent -#200	Rock: % Recovery	RQD	Fractures/ft	Weathering	Strength	Description
0															
5															**0-7' Silty Sand (SM)** Fine, Silty Sand with crushed rock fragments, Trace building debris (wood, concrete, metal), Greyish brown, Occasional dark brown sandy clay seams, Dry, Loose. (Waste Rock)
															7-9' Sandy Clay (CL) Sandy Lean Clay, Dark brown, Dry- (Qal)
10															**9 -11' Clayey Sand (SC)** Clayey Sand, Light brown/Tan, Dry- (Qal)
															End of Probe = 11' refusal on sandstone shelf
15															
20															
25															
30															

Notes: 1. Refusal at 11 feet. Sandstone fragments in sampler tube.

Alan Kuhn Associates LLC

BORING LOG

Boring #	AA-07
Sheet 1 of 1	

Project Name	Johnny M. Mine Site
Project Number	JM-1
Location	Section 18, McKinley Co, NM
Surface Elevation	7072.81

Date	
Started	10/16/12
Completed	10/16/12
Backfilled	10/16/12
Backfill = bentonite chips	

Groundwater encountered:	Date	Time	Depth
	Not Encountered		

Logged by: **Ed Loescher**

Drilling Rig: GEOPROBE 6620DT

Driller: Louis Trujillo

Drilling Method: Direct Push

Depth, feet	Graphic Log	Sample No.	Sample Type	SPT Blow Count	Moisture Content	Dry Density (pcf)	Liquid Limit	Plasticity Index	Percent -#200	Rock: % Recovery	Rock: RQD	Rock: Fractures/ft	Rock: Weathering	Rock: Strength	Description
0–6															**0-6' Silty Sand (SM)** Fine, Silty Sand with crushed rock fragments, Trace building debris (wood, concrete, metal), Greyish brown, Occasional dark brown sandy clay seams, Dry, Loose. (Waste Rock)
6–10															**6-10' Sandy Lean Clay (CL)** Sandy Lean Clay, Trace rock fragments, Dark brown/Light brown mix, Dry - (Clay Fill)
10–11.5															**10 -11.5' Organic Clay (OH),** Trace sand silt and hydrocarbons, Black, Wet, Very soft, and Plastic. (Pond Sediment)
11.5–17															**11.5-17' Silty Sand (SM)** Silty Sand, Occasional Clay seams, Light brown/ tan mix, Dry (Qal)
17–20															**17 -20 Lean Clay (CL)** Hard Lean Clay, Trace sand and shale fragments, Dark brown, Dry- (Weathered Mancos Shale)
20															End of probe = 20' below ground surface.

Depth scale: 0, 5, 10, 15, 20, 25, 30

Alan Kuhn Associates LLC

BORING LOG

Boring #	AA-08
Sheet 1 of 1	

Project Name	**Johnny M. Mine Site**	Date	Started	10/16/12	Groundwater encountered:	Date / Time / Depth	Not Encountered
Project Number	**JM-1**		Completed	10/16/12			
Location	**Section 18, McKinley Co, NM**		Backfilled	10/16/12			
Surface Elevation	7074.09		Backfill = bentonite chips		Logged by:	**Ed Loescher**	

Drilling Rig: GEOPROBE 6620DT

Driller: Louis Trujillo

Drilling Method: Direct Push

Depth, feet	Graphic Log	Sample No.	Sample Type	SPT Blow Count	Moisture Content	Dry Density (pcf)	Liquid Limit	Plasticity Index	Percent -#200	Rock: % Recovery	RQD	Fractures/ft	Weathering	Strength	Description
0–6															**0-6' Silty Sand (SM)** Fine, Silty Sand with crushed rock fragments, Trace building debris (wood, concrete, metal), Greyish brown, Occasional dark brown sandy clay seams, Dry, Loose. (Waste Rock)
6–10															**6-10' Clayey Sand (SC)** Clayey Sand, Trace rock fragments, Dark brown/Light brown mix, Dry - (Clayey Sand Fill)
10–17															**10 -17' Organic Clay (OH),** Trace sand silt and hydrocarbons, Black, Wet, Very soft and Plastic. (Pond Sediment)
17–20															**17-20' Silty Sand (SM)** Silty Sand, Occasional Clay seams, Light brown/ tan mix, Dry (Qal)
20–															**20-24' Sandy Clay (CL)** - Sandy Lean Clay, Light

Depth scale: 0, 5, 10, 15, 20

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BORING LOG

Boring #	AA-09
	Sheet 1 of 2

Project Name	Johnny M. Mine Site	Started	10/16/12
Project Number	JM-1	Completed	10/16/12
Location	Section 18, McKinley Co, NM	Backfilled	10/16/12
Surface Elevation	7077.34	Backfill = bentonite chips	

Groundwater encountered:	Date	Time	Depth
	Not Encountered		
Logged by:	Ed Loescher		

Drilling Rig: GEOPROBE 6620DT

Driller: Louis Trujillo

Drilling Method: Direct Push

Depth, feet	Graphic Log	Sample No.	Sample Type	SPT Blow Count	Moisture Content	Dry Density (pcf)	Liquid Limit	Plasticity Index	Percent -#200	Rock: % Recovery	RQD	Fractures/ft	Weathering	Strength	Description
0–6															**0-6' Silty Sand (SM)** Fine, Silty Sand with crushed rock fragments, Trace building debris (wood, concrete, metal), Greyish brown, Occasional dark brown sandy clay seams, Dry, Loose. (Waste Rock)
6–11															**6-11' Clayey Sand (SC)** Clayey Sand, Trace rock fragments, Brown/Grey mix, Dry - (Clayey Sand Fill)
11–19															**11 -19' Organic Clay (OH)**, Trace sand silt and hydrocarbons, Black, Wet, Very Soft and Plastic. (Pond Sediment)
19–21															

Depth scale: 0, 5, 10, 15, 20

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BORING LOG

Boring #	AA-10
Sheet 1 of 1	

Project Name	**Johnny M. Mine Site**	Date: Started	10/15/12
Project Number	**JM-1**	Completed	10/15/12
Location	**Section 18, McKinley Co, NM**	Backfilled	10/15/12
Surface Elevation	7078.3	Backfill = bentonite chips	

Groundwater encountered:	Date	Time	Depth
	Not Encountered		
Logged by:	**Ed Loescher**		

Drilling Rig:	GEOPROBE 6620DT
Driller:	Louis Trujillo
Drilling Method:	Direct Push

Depth, feet	Graphic Log	Sample No.	Sample Type	SPT Blow Count	Moisture Content	Dry Density (pcf)	Liquid Limit	Plasticity Index	Percent -#200	Rock: % Recovery	RQD	Fractures/ft	Weathering	Strength	Description
0–5															**0-5' Silty Sand (SM)** Fine, Silty Sand with crushed rock fragments, Trace building debris (wood, concrete, metal), Greyish brown, Occasional dark brown sandy clay seams, Dry, Loose. (Waste Rock)
5–10															**5-10' Clayey Sand (SC)** Clayey Sand, Trace rock fragments, Brown/Dark Brown mix, Dry - (Clayey Sand Fill)
10–14															**10 -14' Organic Clay (OH),** Trace sand silt and hydrocarbons, Black, Wet, Very soft and Plastic. (Pond Sediment)
14–16															**14-16' Sandy Clay (CL)** - Sandy Lean Clay, Brown with dark brown seams, Hard, Dry. (Qal)
16															End of probe = 16' below ground surface.
20															

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BORING LOG

Boring # **AA-11**

Sheet 1 of 1

Project Name	**Johnny M. Mine Site**	Started	10/15/12
Project Number	**JM-1**	Completed	10/15/12
Location	**Section 18, McKinley Co, NM**	Backfilled	10/15/12
Surface Elevation	7082.02	Backfill = bentonite chips	

Groundwater encountered:

Date	Time	Depth
Not Encountered		

Logged by: **Ed Loescher**

Drilling Rig: GEOPROBE 6620DT

Driller: Louis Trujillo

Drilling Method: Direct Push

Depth, feet	Graphic Log	Sample No.	Sample Type	SPT Blow Count	Moisture Content	Dry Density (pcf)	Liquid Limit	Plasticity Index	Percent -#200	Rock: % Recovery	Rock: RQD	Rock: Fractures/ft	Rock: Weathering	Rock: Strength	Description
0															**0-2.8' Silty Sand (SM)** Fine, Silty Sand with crushed rock fragments, Trace building debris (wood, concrete, metal), Greyish brown, Occasional dark brown sandy clay seams, Dry, Loose. (Waste Rock)
5															**2.8 - 8' Clayey Sand (SC)** Clayey Sand, Some silt, Occasional dark brown clay seams, Light brown/Tan, Slight cementation, Dry- (Qal)
															End of probe = 8' below ground surface
10															
15															
20															

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BORING LOG

Boring #	AA-12
Sheet 1 of 1	

Project Name	**Johnny M. Mine Site**	Date: Started	10/15/12
Project Number	**JM-1**	Completed	10/15/12
Location	**Section 18, McKinley Co, NM**	Backfilled	10/15/12
Surface Elevation	7076.3	Backfill = bentonite chips	

Groundwater encountered:	Date	Time	Depth
	Not Encountered		
Logged by:	**Ed Loescher**		

Drilling Rig: GEOPROBE 6620DT

Driller: Louis Trujillo

Drilling Method: Direct Push

Depth, feet	Graphic Log	Sample No.	Sample Type	SPT Blow Count	Moisture Content	Dry Density (pcf)	Liquid Limit	Plasticity Index	Percent -#200	Rock: % Recovery	RQD	Fractures/ft	Weathering	Strength	Description
0															**0-1' Silty Sand (SM)** Fine, Silty Sand with crushed rock fragments, Trace building debris (wood, concrete, metal), Greyish brown, Occasional dark brown sandy clay seams, Dry, Loose. (Waste Rock)
															1-4' Sandy Clay, **(CL)** - Sandy Clay , trace sandstone and shale fragments, Occasional sand seams, dark brown, dry (Qal)
5															**4 - 8' Clayey Sand (SC)** Clayey Sand, Some silt, Occasional dark brown clay seams, Light brown/Tan,Slight cementation, Dry- (Qal)
															End of probe = 8' below ground surface
10															
15															
20															

Alan Kuhn Associates LLC

BORING LOG

Boring #	GEOA-01
Sheet 1 of 1	

Project Name	**Johnny M. Mine Site**	Date	Started	11/9/12	Groundwater encountered:	Date / Time / Depth: Not Encountered
Project Number	**JM-1**		Completed	11/9/12		
Location	**Section 18, McKinley Co, NM**		Backfilled	11/9/12		
Surface Elevation	7073.4		Backfill = bentonite chips		Logged by:	**Ed Loescher**

Drilling Rig: GEOPROBE 6620DT

Driller: Louis Trujillo

Drilling Method: Direct Push

Depth, feet	Graphic Log	Sample No.	Sample Type	SPT Blow Count	Moisture Content	Dry Density (pcf)	Liquid Limit	Plasticity Index	Percent -#200	Rock: % Recovery	Rock: RQD	Rock: Fractures/ft	Rock: Weathering	Rock: Strength	Description
0–17															**0-17' Silty Sand (SM)** - Fine, Silty Sand with crushed rock fragments, Trace building debris (wood, concrete, metal), Greyish brown, Occasional dark brown sandy clay seams, Dry, Loose. (Waste Rock)
17–24															**17-24' Silty Sand (SM)** Silty Sand, Occasional Clay seams, Light brown/ tan mix, Dry (Qal)
24–28															**24-28' Lean Clay (CL)** Very Hard Lean Clay, Trace sand and shale fragments, Dark brown, Dry- (Weathered Mancos Shale)
28															End of Probe =28' feet below ground surface

Depth scale: 0, 5, 10, 15, 20, 25, 30

Alan Kuhn Associates LLC

BORING LOG

Boring # **GEOA-02**

Sheet 1 of 1

Project Name	**Johnny M. Mine Site**	Date: Started	11/9/12
Project Number	**JM-1**	Date: Completed	11/9/12
Location	**Section 18, McKinley Co, NM**	Date: Backfilled	11/9/12
Surface Elevation	7060.1	Backfill = bentonite chips	

Groundwater encountered:	Date	Time	Depth
	Not Encountered		

Logged by: **Ed Loescher**

Drilling Rig: GEOPROBE 6620DT

Driller: Louis Trujillo

Drilling Method: Direct Push

Depth, feet	Graphic Log	Sample No.	Sample Type	SPT Blow Count	Moisture Content	Dry Density (pcf)	Liquid Limit	Plasticity Index	Percent -#200	Rock: % Recovery	Rock: RQD	Rock: Fractures/ft	Rock: Weathering	Rock: Strength	Description
0–11															**0-11' Silty Sand (SM)** - Fine, Silty Sand with crushed rock fragments, Trace building debris (wood, concrete, metal), Greyish brown, Occasional dark brown sandy clay seams, Dry, Loose. (Waste Rock)
11–14															**11-14' Poorly Graded Sand (SP-SM)** Poorly Graded sand with silt,Light brown/ tan mix, Dry (Qal)
15		**S1**			**8.8**				**31**						
14–20															**14-20' Silty Sand (SM)** Silty Sand, Occasional Clay seams, Light brown/ tan mix, Dry (Qal)
20–24															**20-24' Lean Clay (CL)** Very Hard Lean Clay, Trace sand and shale fragments, Dark brown, Dry- (Weathered Mancos Shale)
24															End of Probe =24' feet below ground surface

Depth scale: 0, 5, 10, 15, 20, 25, 30

Alan Kuhn Associates LLC

BORING LOG

Boring #	GEOA-03
Sheet 1 of 1	

Project Name	**Johnny M. Mine Site**	Date: Started	11/9/12
Project Number	**JM-1**	Date: Completed	11/9/12
Location	**Section 18, McKinley Co, NM**	Date: Backfilled	11/9/12
Surface Elevation	7054.3	Backfill = bentonite chips	

Groundwater encountered:	Date	Time	Depth
	Not Encountered		

Logged by: **Ed Loescher**

Drilling Rig: GEOPROBE 6620DT

Driller: Louis Trujillo

Drilling Method: Direct Push

Depth, feet	Graphic Log	Sample No.	Sample Type	SPT Blow Count	Moisture Content	Dry Density (pcf)	Liquid Limit	Plasticity Index	Percent -#200	Rock: % Recovery	Rock: RQD	Rock: Fractures/ft	Rock: Weathering	Rock: Strength	Description
0															
5															**0-12' Silty Sand (SM)** - Fine, Silty Sand with crushed rock fragments, Trace building debris (wood, concrete, metal), Greyish brown, Occasional dark brown sandy clay seams, Dry, Loose. (Waste Rock)
10															
		S1							**8**						
15															**12-20' Poorly Graded Sand (SP-SM)** Poorly Graded sand with silt,Light brown/ tan mix, Dry (Qal)
20															**20-24' Lean Clay (CL)** Very Hard Lean Clay, Trace sand and shale fragments, Dark brown, Dry- (Weathered Mancos Shale)
25															End of Probe =24' feet below ground surface
30															

Alan Kuhn Associates LLC

BORING LOG

Boring #	GEOA-04
Sheet 1 of 1	

Project Name	Johnny M. Mine Site	Date	Started	11/9/12	
Project Number	JM-1		Completed	11/9/12	
Location	Section 18, McKinley Co, NM		Backfilled	11/9/12	
Surface Elevation	7045.3		Backfill = bentonite chips		

Groundwater encountered:	Date	Time	Depth
	Not Encountered		

Logged by: **Ed Loescher**

Drilling Rig: GEOPROBE 6620DT

Driller: Louis Trujillo

Drilling Method: Direct Push

Depth, feet	Graphic Log	Sample No.	Sample Type	SPT Blow Count	Moisture Content	Dry Density (pcf)	Liquid Limit	Plasticity Index	Percent -#200	Rock: % Recovery	RQD	Fractures/ft	Weathering	Strength	Description
0															**0-1' Silty Sand (SM)** - Fine, Silty Sand with crushed rock fragments, Trace building debris (wood, concrete, metal), Greyish brown, Occasional dark brown sandy clay seams, Dry, Loose. (Waste Rock)
5															**1-12' Poorly Graded Sand (SP-SM)** Poorly Graded sand with silt,Light brown/ tan mix, Dry (Qal)
10															
15															**12-24' Silty Sand (SM)** Silty Sand, Occasional Clay seams, Light brown/ tan mix, Dry (Qal)
20															
		S1			3.8				26						
25															**24-28' Lean Clay (CL)** Very Hard Lean Clay, Trace sand and shale fragments, Dark brown, Dry- (Weathered Mancos Shale)
30															**28-32'** Weathered Mancos Shale

End of Probe =32' feet below ground surface

Alan Kuhn Associates LLC

BORING LOG

Boring # **GEOA-05**

Sheet 1 of 1

Project Name	**Johnny M. Mine Site**	Date: Started	11/9/12
Project Number	**JM-1**	Completed	11/9/12
Location	**Section 18, McKinley Co, NM**	Backfilled	11/9/12
Surface Elevation	7062.8	Backfill = bentonite chips	

Groundwater encountered:	Date	Time	Depth
	Not Encountered		

Logged by: **Ed Loescher**

Drilling Rig: GEOPROBE 6620DT

Driller: Louis Trujillo

Drilling Method: Direct Push

Depth, feet	Graphic Log	Sample No.	Sample Type	SPT Blow Count	Moisture Content	Dry Density (pcf)	Liquid Limit	Plasticity Index	Percent -#200	Rock: % Recovery	RQD	Fractures/ft	Weathering	Strength	Description
0–12															**0-12' Silty Sand (SM)** - Fine, Silty Sand with crushed rock fragments, Trace building debris (wood, concrete, metal), Greyish brown, Occasional dark brown sandy clay seams, Dry, Loose. (Waste Rock)
12–18		**S1**			**5.6**				**50**						**12-18' Silty Sand (SM)** Silty Sand, Occasional Clay seams, Light brown/ tan mix, Dry (Qal)
18–26															**18-26' Poorly Graded Sand (SP-SM)** Poorly Graded sand with silt,Light brown/ tan mix, Dry (Qal)
26–28		**S2**			**9.5**				**82**						**26-28' Lean Clay (CL)** Very Hard Lean Clay, Trace sand and shale fragments, Dark brown, Dry- (Weathered Mancos Shale)
															End of Probe =28' feet below ground surface

Depth scale: 0, 5, 10, 15, 20, 25, 30

Alan Kuhn Associates LLC

BORING LOG

Boring #	GEOA-06
	Sheet 1 of 1

Project Name	Johnny M. Mine Site	Date: Started	11/9/12
Project Number	JM-1	Date: Completed	11/9/12
Location	Section 18, McKinley Co, NM	Date: Backfilled	11/9/12
Surface Elevation	7066.1	Backfill = bentonite chips	

Groundwater encountered:	Date	Time	Depth
	Not Encountered		

Logged by: **Ed Loescher**

Drilling Rig: GEOPROBE 6620DT

Driller: Louis Trujillo

Drilling Method: Direct Push

Depth, feet	Graphic Log	Sample No.	Sample Type	SPT Blow Count	Moisture Content	Dry Density (pcf)	Liquid Limit	Plasticity Index	Percent -#200	Rock: % Recovery	Rock: RQD	Rock: Fractures/ft	Rock: Weathering	Rock: Strength	Description
0															**0-4' Silty Sand (SM)** - Fine, Silty Sand with crushed rock fragments, Trace building debris (wood, concrete, metal), Greyish brown, Occasional dark brown sandy clay seams, Dry, Loose. (Waste Rock)
5															**4-6' Poorly Graded Sand (SP-SM)** Poorly Graded sand with silt,Light brown/ tan mix, Dry (Qal)
															6-8' Sandy Clay (CL) - Sandy Lean Clay, Light brown, Hard, Dry. (Qal)
10															**8-16' Poorly Graded Sand (SP)** Poorly Graded sand, Trace silt, Light Tan/White, Dry (Qal)
15															**16-19' Silty Sand (SM)** Silty Sand, Occasional Clay seams, Light brown/ tan mix, Dry (Qal)
20															**19-24' Lean Clay (CL)** Very Hard Lean Clay, Trace sand and shale fragments, Dark brown, Dry- (Weathered Mancos Shale)
25															End of Probe =24' feet below ground surface
30															

Alan Kuhn Associates LLC

BORING LOG

Boring #	GEOB-01
	Sheet 1 of 1

Project Name	**Johnny M. Mine Site**	Date	Started	11/9/12	Groundwater encountered: Date / Time / Depth — Not Encountered
Project Number	**JM-1**		Completed	11/9/12	
Location	**Section 18, McKinley Co, NM**		Backfilled	11/9/12	
Surface Elevation			Backfill = Hand Dig		Logged by: **Ed Loescher**

Drilling Rig: Hand Shovel

Driller: Ed Loescher

Drilling Method: Hand Dig

Depth, feet	Graphic Log	Sample No.	Sample Type	SPT Blow Count	LAB: Moisture Content %	Dry Density (pcf)	Liquid Limit	Plasticity Index	Percent -#200	Optimum Moisture %	Optimum Density (PCF)			Description
0		S1	G		4.3		30	11	40	12	117.6			**0-1' Clayey Sand (SC)** Clayey Sand, Trace rock fragments, Brown/Dark Brown mix, Dry - (Qal)
5														
10														
15														
20														
25														
30														

Alan Kuhn Associates LLC

BORING LOG

Boring #	GEOB-02
Sheet 1 of 1	

Project Name	Johnny M. Mine Site	Date	Started	11/9/12	Groundwater encountered:	Date / Time / Depth: Not Encountered
Project Number	JM-1		Completed	11/9/12		
Location	Section 18, McKinley Co, NM		Backfilled	11/9/12		
Surface Elevation			Backfill = Hand Dig		Logged by:	Ed Loescher

Drilling Rig: Hand Shovel

Driller: Ed Loescher

Drilling Method: Hand Dig

Depth, feet	Graphic Log	Sample No.	Sample Type	SPT Blow Count	LAB: Moisture Content %	Dry Density (pcf)	Liquid Limit	Plasticity Index	Percent -#200	Optimum Moisture %	Optimum Density (PCF)			Description
0		S1	G		4		35	13	56	15	106.8			**0-1' Sandy Lean Clay (CL)** Sandy Lean Clay, Trace rock fragments, Brown/Dark Brown mix, Dry - (Qal)
5														
10														
15														
20														
25														
30														

Alan Kuhn Associates LLC

BORING LOG

Boring #	GEOB-03
Sheet 1 of 1	

Project Name	**Johnny M. Mine Site**	Date	Started	11/9/12
Project Number	**JM-1**		Completed	11/9/12
Location	**Section 18, McKinley Co, NM**		Backfilled	11/9/12
Surface Elevation			Backfill = Hand Dig	

Groundwater encountered:	Date	Time	Depth
	Not Encountered		
Logged by:	**Ed Loescher**		

Drilling Rig:	Hand Shovel
Driller:	Ed Loescher
Drilling Method:	Hand Dig

Depth, feet	Graphic Log	Sample No.	Sample Type	SPT Blow Count	LAB: Moisture Content %	LAB: Dry Density (pcf)	LAB: Liquid Limit	LAB: Plasticity Index	LAB: Percent -#200	LAB: Optimum Moisture %	LAB: Optimum Density (PCF)			Description
0		S1	G		5.1		39	18	74	19	99			**0-1' Sandy Lean Clay (CL)** Sandy Lean Clay, Trace rock fragments, Brown/Dark Brown mix, Dry - (Qal)
5														
10														
15														
20														
25														
30														

Alan Kuhn Associates LLC

BORING LOG

Boring #	**GEOB-04**
Sheet 1 of 1	

Project Name	**Johnny M. Mine Site**	Date	Started	11/9/12	Groundwater encountered:	Date	Time	Depth
Project Number	**JM-1**		Completed	11/9/12		Not Encountered		
Location	**Section 18, McKinley Co, NM**		Backfilled	11/9/12				
Surface Elevation			Backfill = Hand Dig		Logged by:	**Ed Loescher**		

Drilling Rig:	Hand Shovel
Driller:	Ed Loescher
Drilling Method:	Hand Dig

Depth, feet	Graphic Log	Sample No.	Sample Type	SPT Blow Count	LAB Moisture Content %	LAB Dry Density (pcf)	LAB Liquid Limit	LAB Plasticity Index	LAB Percent -#200	LAB Optimum Moisture %	LAB Optimum Density (PCF)			Description
0		S1	G		3.3		NV	NP	21	10	120.2			**0-1' Silty Sand (SM)** Fine, Silty Sand with crushed rock fragments, Trace building debris (wood, concrete, metal), Greyish brown, Occasional dark brown sandy clay seams, Dry, Loose. (Waste Rock)
5														
10														
15														
20														
25														
30														

Alan Kuhn Associates LLC

BORING LOG

Boring # **GEOB-05**

Sheet 1 of 1

Project Name	**Johnny M. Mine Site**	Date: Started	11/9/12
Project Number	**JM-1**	Date: Completed	11/9/12
Location	**Section 18, McKinley Co, NM**	Date: Backfilled	11/9/12
Surface Elevation		Backfill = Hand Dig	

Groundwater encountered:	Date	Time	Depth
	Not Encountered		

Logged by: **Ed Loescher**

Drilling Rig: Hand Shovel

Driller: Ed Loescher

Drilling Method: Hand Dig

Depth, feet	Graphic Log	Sample No.	Sample Type	SPT Blow Count	LAB: Moisture Content %	LAB: Dry Density (pcf)	LAB: Liquid Limit	LAB: Plasticity Index	LAB: Percent -#200	LAB: Optimum Moisture %	LAB: Optimum Density (PCF			Description
0		S1	G											**0-1' Silty Sand (SM)** Fine, Silty Sand with crushed rock fragments, Trace building debris (wood, concrete, metal), Greyish brown, Occasional dark brown sandy clay seams, Dry, Loose. (Waste Rock)
5														
10														
15														
20														
25														
30														

Alan Kuhn Associates LLC

BORING LOG

Boring #	GEOB-06
Sheet 1 of 1	

Project Name	**Johnny M. Mine Site**	Date: Started	11/9/12	Groundwater encountered: Date / Time / Depth	Not Encountered
Project Number	**JM-1**	Date: Completed	11/9/12		
Location	**Section 18, McKinley Co, NM**	Date: Backfilled	11/9/12		
Surface Elevation		Backfill = Hand Dig		Logged by:	**Ed Loescher**

Drilling Rig: Hand Shovel

Driller: Ed Loescher

Drilling Method: Hand Dig

Depth, feet	Graphic Log	Sample No.	Sample Type	SPT Blow Count	LAB: Moisture Content %	LAB: Dry Density (pcf)	LAB: Liquid Limit	LAB: Plasticity Index	LAB: Percent -#200	LAB: Optimum Moisture %	LAB: Optimum Density (PCF)	Description
0		S1	G		1.9		NV	NP	21	9.6	120.6	**0-1' Silty Sand (SM)** Fine, Silty Sand with crushed rock fragments, Trace building debris (wood, concrete, metal), Greyish brown, Occasional dark brown sandy clay seams, Dry, Loose. (Waste Rock)
5												
10												
15												
20												
25												
30												

Alan Kuhn Associates LLC

BORING LOG

Boring #	GEOR-01
Sheet 1 of 1	

Project Name	**Johnny M. Mine Site**	Date	Started	11/9/12	Groundwater encountered: Date / Time / Depth — Not Encountered
Project Number	**JM-1**		Completed	11/9/12	
Location	**Section 18, McKinley Co, NM**		Backfilled	11/9/12	
Surface Elevation			Backfill = NA		Logged by: **Ed Loescher**

Drilling Rig: Hand Pick

Driller: Ed Loescher

Drilling Method: Hand

Depth, feet	Graphic Log	Sample No.	Sample Type	SPT Blow Count	LAB: Moisture Content %	Dry Density (pcf)	Liquid Limit	Plasticity Index	Percent -#200	Optimum Moisture %	Optimum Density (PCF			Description
0		S1	G											**Ground Surface Sandstone Outcrop**
5														
10														
15														
20														
25														
30														

Alan Kuhn Associates LLC

BORING LOG

Boring #	GEOR-02
Sheet 1 of 1	

Project Name	**Johnny M. Mine Site**	Date	Started	11/9/12
Project Number	**JM-1**		Completed	11/9/12
Location	**Section 18, McKinley Co, NM**		Backfilled	11/9/12
Surface Elevation			Backfill = NA	

Groundwater encountered:	Date	Time	Depth
	Not Encountered		
Logged by:	**Ed Loescher**		

Drilling Rig:	Hand Pick
Driller:	Ed Loescher
Drilling Method:	Hand

Depth, feet	Graphic Log	Sample No.	Sample Type	SPT Blow Count	LAB: Moisture Content %	LAB: Dry Density (pcf)	LAB: Liquid Limit	LAB: Plasticity Index	LAB: Percent -#200	LAB: Optimum Moisture %	LAB: Optimum Density (PCF)			Description
0		S1	G											**Ground Surface Sandstone Outcrop**
5														
10														
15														
20														
25														
30														

Alan Kuhn Associates LLC

BORING LOG

Boring #	GEOR-03
Sheet 1 of 1	

Project Name	**Johnny M. Mine Site**	Date: Started	11/9/12
Project Number	**JM-1**	Date: Completed	11/9/12
Location	**Section 18, McKinley Co, NM**	Date: Backfilled	11/9/12
Surface Elevation		Backfill = NA	

Groundwater encountered:	Date	Time	Depth
	Not Encountered		

Logged by: **Ed Loescher**

Drilling Rig: Hand Pick

Driller: Ed Loescher

Drilling Method: Hand

Depth, feet	Graphic Log	Sample No.	Sample Type	SPT Blow Count	LAB: Moisture Content %	LAB: Dry Density (pcf)	LAB: Liquid Limit	LAB: Plasticity Index	LAB: Percent -#200	LAB: Optimum Moisture %	LAB: Optimum Density (PCF			Description
0		S1	G											**Ground Surface Sandstone Outcrop**
5														
10														
15														
20														
25														
30														

Appendix G

Geotechnical Laboratory Results

Sample No.	Moisture Content (%)	Liquid Limit	Plasticity Index	Percent Passing - U.S. Sieve Numbers										USCS Class
				1-1/2"	3/4"	3/8"	No. 4	No. 8	No. 16	No. 30	No. 50	N0. 100	No. 200	
GEOA-02-S1	8.8	NV	NP				100	99	99	99	93	53	30.7	SM
GEOA-03-S1										100	87	17	8.0	SP-SM
GEOA-04-S1	3.8					100	98	97	96	95	94	62	26.3	SM
GEOA-05-S1	5.6					100	99	97	96	95	91	67	49.5	SM
GEOA-05-S2	9.5	46	27			100	99	99	98	97	94	89	82.1	CL
GEOB-01-S1		30	11	100	92	86	78	70	64	59	56	46	39.5	SC
GEOB-02-S1		35	13	100	99	93	90	85	78	71	66	61	56.1	CL
GEOB-03-S1		39	18	100	99	97	96	94	92	90	87	82	74.4	CL
GEOB-04-S1		NV	NP	100	94	92	91	89	87	81	60	33	20.7	SM
GEOB-05-S1				100	99	98	95	93	91	85	64	36	24.3	SM
GEOB-06-S1		NV	NP	100	94	93	91	89	86	78	57	31	21.3	SM
AA-01-SS-0015-101512-GEO				100	95	93	91	88	86	82	73	50	35.1	SM
AA-03-SS-0015-101512-GEO					100	95	93	92	89	83	67	46	34.8	SM
AA-04-SS-0015-102212-GEO					100	99	97	94	92	86	65	36	25.1	SM
AA-06-SS-0015-101612-GEO					100	99	97	95	93	89	76	47	32.7	SM
AA-07-SS-0015-101612-GEO					100	98	94	91	87	84	71	38	25.1	SM
AA-08-SS-0015-101012-GEO						100	98	96	94	88	67	37	30.1	SM
AA-09-SS-0015-101612-GEO					100	95	93	90	88	82	75	34	22.1	SM
AA-10-SS-0015-101512-GEO					100	99	97	96	94	89	70	40	26.0	SM
AA-11-SS-0015-101512-GEO				100	91	86	86	83	80	76	63	41	31.6	SM
AA-12-SS-0015-101512-GEO					100	96	93	90	87	81	69	48	37.0	SM

PROCTOR TEST RESULTS

Project: Johnny M
EEG Project No.: A12-756
Sample: Geo B-01
Method: ASTM D-698, A, Dry, Manual

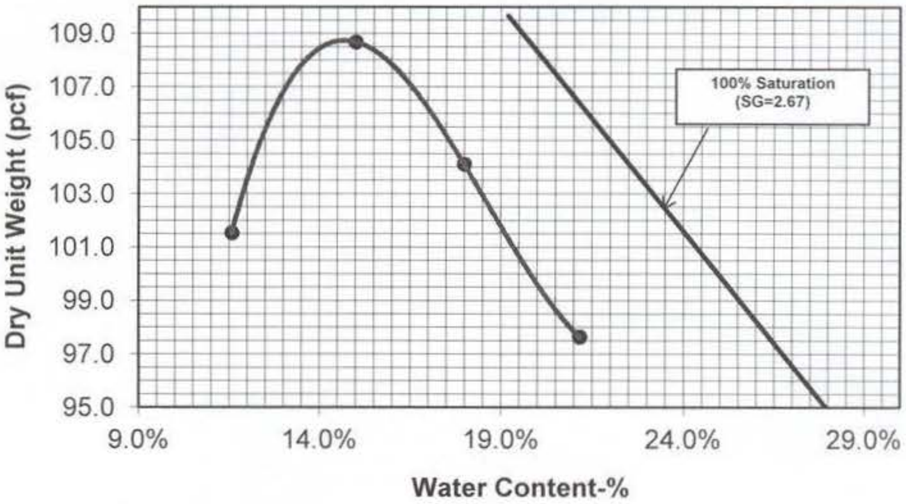
Unified Classification: SC
Description: Clayey Sand

As Received Moisture Content: 4.3%

Sieve:	1	3/4	3/8	No. 4	No. 8	No. 16	No. 30	No. 50	No. 100	No. 200
Percent Passing:	100.0%	92.3%	86.3%	78.3%	69.8%	63.6%	59.3%	55.5%	45.5%	39.5%

Liquid Limit: 30%
Plasticity Index: 11%

Compaction Curve:



Oversize Correction Data:

Fine Fraction:	78.3%
Fine Fraction Moisture Content:	14.7%
Dry Unit Weight of Fine Fraction:	108.7
Coarse Fraction:	21.7%
Bulk Specific Gravity:	2.67
Coarse Aggregate Moisture Content:	1.7%

Max Dry Unit Weight (pcf):	117.6
Opt. Water Content (%):	11.9%

Estimated R-Value

Earthworks Engineering Group, LLC
7901 Lorraine Ct NE
Albuquerque, NM 87113
(505) 899-4886

PROCTOR TEST RESULTS

Project: Johnny M
EEG Project No.: A12-756
Sample: Geo B-02
Method: ASTM D-698, A, Dry, Manual

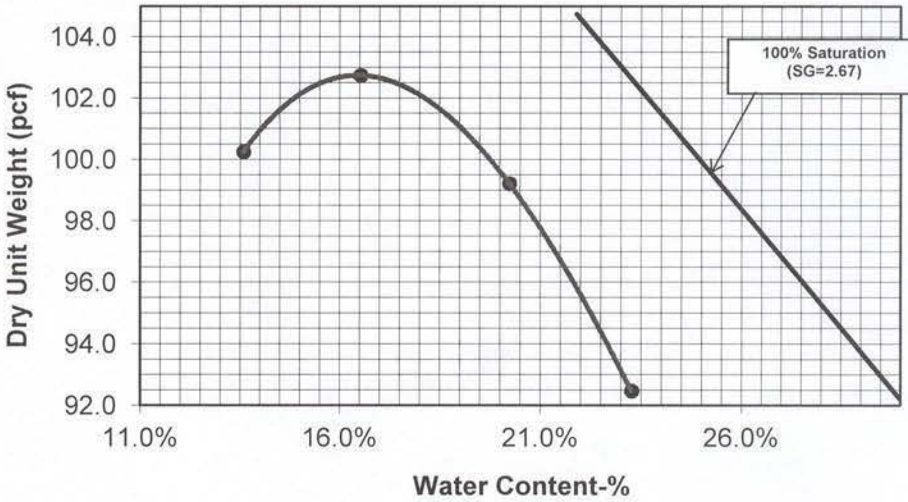
Unified Classification: CL
Description: Lean Clay

As Received Moisture Content: 4.0%

Sieve:	1	3/4	3/8	No. 4	No. 8	No. 16	No. 30	No. 50	No. 100	No. 200
Percent Passing:	100.0%	98.7%	92.8%	90.1%	84.8%	78.3%	71.2%	65.5%	61.2%	56.1%

Liquid Limit: 35%
Plasticity Index: 13%

Compaction Curve:



Oversize Correction Data:

Fine Fraction:	90.1%
Fine Fraction Moisture Content:	16.5%
Dry Unit Weight of Fine Fraction:	102.7
Coarse Fraction:	9.9%
Bulk Specific Gravity:	2.67
Coarse Aggregate Moisture Content:	1.7%

Max Dry Unit Weight (pcf):	106.8
Opt. Water Content (%):	15.0%

Estimated R-Value

Earthworks Engineering Group, LLC
7901 Lorraine Ct NE
Albuquerque, NM 87113
(505) 899-4886

PROCTOR TEST RESULTS

Project: Johnny M
EEG Project No.: A12-756
Sample: Geo B-03
Method: ASTM D-698, A, Dry, Manual

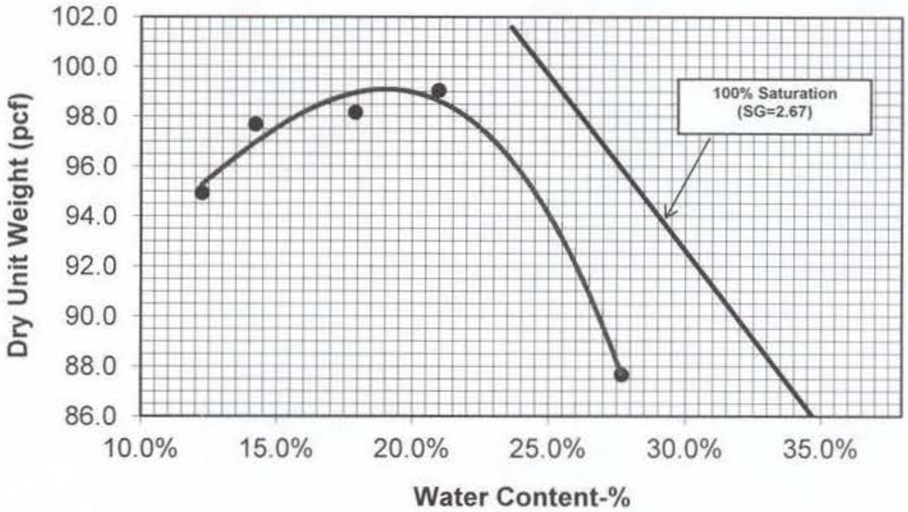
Unified Classification: CL
Description: Lean Clay

As Received Moisture Content: 5.1%

Sieve:	1	3/4	3/8	No. 4	No. 8	No. 16	No. 30	No. 50	No. 100	No. 200
Percent Passing:	100.0%	99.0%	97.4%	96.1%	93.9%	91.6%	89.5%	87.1%	82.3%	74.4%

Liquid Limit: 39%
Plasticity Index: 18%

Compaction Curve:



Oversize Correction Data:

Fine Fraction:	-
Fine Fraction Moisture Content:	-
Dry Unit Weight of Fine Fraction:	-
Coarse Fraction:	-
Bulk Specific Gravity:	-
Coarse Aggregate Moisture Content:	-

Max Dry Unit Weight (pcf):	99.0
Opt. Water Content (%):	19.2%

Estimated R-Value

Earthworks Engineering Group, LLC
7901 Lorraine Ct NE
Albuquerque, NM 87113
(505) 899-4886

PROCTOR TEST RESULTS

Project: Johnny M
EEG Project No.: A12-756
Sample: Geo B-04
Method: ASTM D-698, A, Dry, Manual

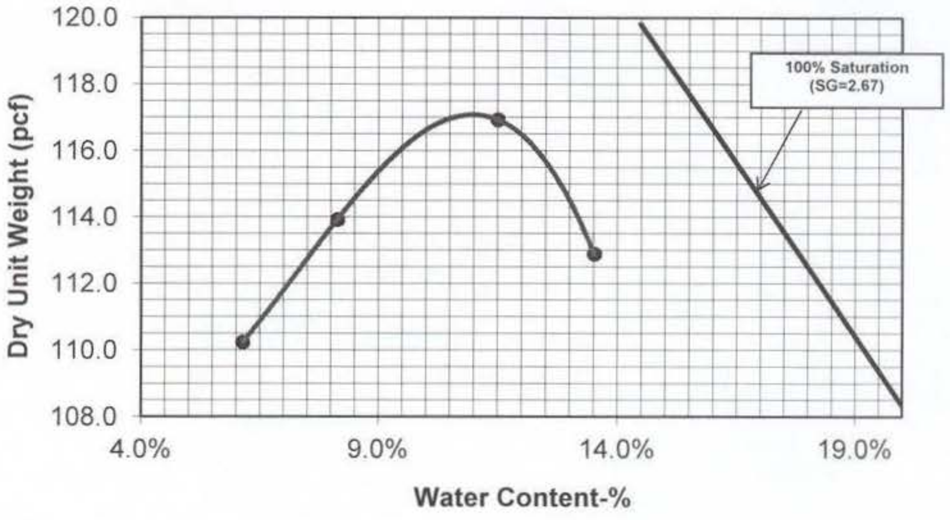
Unified Classification: SM
Description: Silty Sand

As Received Moisture Content: 3.3%

Sieve:	**1**	**3/4**	**3/8**	**No. 4**	**No. 8**	**No. 16**	**No. 30**	**No. 50**	**No. 100**	**No. 200**
Percent Passing:	100.0%	94.0%	92.3%	91.1%	89.2%	86.8%	80.5%	59.8%	33.1%	20.7%

Liquid Limit: NV
Plasticity Index: NP

Compaction Curve:



Oversize Correction Data:

Fine Fraction:	91.1%
Fine Fraction Moisture Content:	11.0%
Dry Unit Weight of Fine Fraction:	117
Coarse Fraction:	8.9%
Bulk Specific Gravity:	2.67
Coarse Aggregate Moisture Content:	1.7%

Max Dry Unit Weight (pcf):	120.2
Opt. Water Content (%):	10.2%

Estimated R-Value

Earthworks Engineering Group, LLC
7901 Lorraine Ct NE
Albuquerque, NM 87113
(505) 899-4886

PROCTOR TEST RESULTS

Project: Johnny M
EEG Project No.: A12-756
Sample: Geo B-06
Method: ASTM D-698, A, Dry, Manual

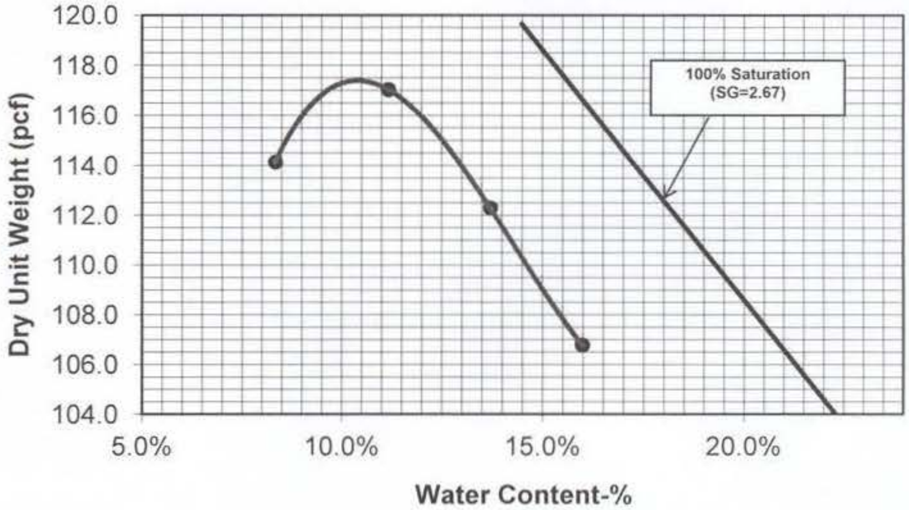
Unified Classification: SM
Description: Silty Sand

As Received Moisture Content: 1.9%

Sieve:	1	3/4	3/8	No. 4	No. 8	No. 16	No. 30	No. 50	No. 100	No. 200
Percent Passing:	100.0%	94.4%	92.6%	90.7%	89.0%	86.4%	77.9%	57.3%	30.6%	21.3%

Liquid Limit: NV
Plasticity Index: NP

Compaction Curve:



Oversize Correction Data:

Fine Fraction:	90.7%
Fine Fraction Moisture Content:	10.4%
Dry Unit Weight of Fine Fraction:	117.3
Coarse Fraction:	9.3%
Bulk Specific Gravity:	2.67
Coarse Aggregate Moisture Content:	1.7%

Max Dry Unit Weight (pcf):	120.6
Opt. Water Content (%):	9.6%

Estimated R-Value

Earthworks Engineering Group, LLC
7901 Lorraine Ct NE
Albuquerque, NM 87113
(505) 899-4886

Appendix H

Radionuclide, Indicator Metals, and Pond Sediment Characterization Laboratory Results

(Data Provided Separately on Compact Disc)

Appendix I

Groundwater Report

ANALYSIS OF GROUNDWATER CONDITIONS
AT THE FORMER JOHNNY M MINE
MCKINLEY COUNTY, NEW MEXICO

Prepared
for
Hecla Limited
Coeur d'Alene, Idaho

Prepared
by
Itasca Denver, Inc.

March 2013

ITASCA™
Denver, Inc.

ITASCA Denver, Inc.

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1.0 INTRODUCTION

Itasca Denver, Inc., (Itasca) was asked by Hecla Limited (Hecla) to review existing geologic, hydrogeologic, and geochemical data related to the former Johnny M Mine (Project Area) and surrounding area, located in McKinley County, New Mexico (Figure 1). Itasca was requested to address the following questions regarding potential groundwater and surface-water quality impacts associated with the Project Area:

- Is shallow groundwater quality in the Project Area affected by mine water during operations or leaching from mined materials?
- Has the groundwater quality of the former domestic wells in the Project Area (GMD-04 and/or GMD-05) or other groundwater resources been affected by mining-related activity in the Project Area?
- Is the quality of groundwater in the Project area affected by the presence of backfilled tailing sand in the underground workings?

The following sections provide a description of the geology, hydrogeology, and geochemistry of the Project Area and discuss Itasca's evaluation of these water-quality questions.

1.1 BACKGROUND

The Johnny M uranium deposit was discovered in November 1968 and work began on sinking a shaft in late 1972. Ore in the Johnny M Mine came from the Poison Canyon tongue of the Morrison Formation Brushy Basin Member and from a zone near the top of the Morrison Formation Westwater Canyon Member, at depths of between 1,300 and 1,400 feet below ground surface (ft bgs). Production appears to have started in 1976 with the shipment of low-grade ore to Kerr McGee's uranium mill located at Ambrosia Lake. No milling occurred on site; all ore was shipped off site for processing. Production at the mine ended in 1982.

The ore-bearing zone originally was saturated, and was dewatered to facilitate mining. Starting in August 1977, backfilling was performed to enhance the geomechanical stability of the stopes (areas of the mine from which ore had been produced). Approximately 286,000 tons of tailings sand were obtained from the Ambrosia Lake mill and placed within the mine to backfill stopes. Backfilling occurred using a mixture of mine-supplied water and sand, which was slurried into the stopes.

Initially mine discharges consisted of water resulting from dewatering and mine operations (e.g., drilling). Later, the slurry water was collected within the mine and pumped to land surface as part of the ongoing mine dewatering operations. (Mine water for purposes of this report includes water derived from groundwater dewatering, drill water, and slurry water.) Pumping from the mine averaged approximately 800 gallons per minute (gpm), and the recovered water was discharged to two treatment ponds that were excavated into native materials (Ponds 1 and 2 are shown in Figure 2). The recovered water was treated in the ponds by the addition of a coagulant and barium chloride, and then discharged to the San Mateo Creek drainage channel via a one-mile open ditch that was later replaced by a 12-inch diameter pipe (Figure 2).

The mine-water discharge plan, as described above, was approved by the New Mexico Environmental Improvement Board. The area to which treated-water discharge occurred is underlain by up to 80 ft of alluvium/colluvium on top of the Mancos Shale. During and after mining, water samples were collected from groundwater monitoring wells and surface-water locations. The locations of these sampling points are indicated in Figure 2. Figure 2 was constructed from three different hand-drawn maps; the locations of several sampling points are deemed approximate. Water samples collected at MW-1 represent the quality of the treated discharge waters from the surface-treatment ponds. A summary of the sampling points is provided in Table 1.

Upon completion of mining, the mine shaft was sealed with a reinforced four-foot-thick engineered concrete plug. The plug was set between the Dakota Formation and the Westwater Canyon Member of the Morrison Formation.

1.2 NEARBY PROJECTS AND OTHER DATA

In addition to the data that were available for the Project Area, the assessment provided in this report also considered data that were available from several nearby projects. A significant amount of geologic, hydrogeologic, and geochemical data were available from the Baseline Data Report (BDR) (Roca Honda Resources 2011) for the proposed Roca Honda (RH) mine that is located approximately one mile directly east of the Project Area (Figure 1). Data were also available from studies associated with the USDA Forest Service Non-Time Critical Removal Action (Science Applications International Corporation 1994) at the former San Mateo Mine that is located approximately two miles south of the Project Area. Geologic information in the Project Area was supplemented from a geologic log for one of the former domestic wells in the Project Area (GMD-04). Lastly, water-quality samples were collected from the two former domestic wells in the Project Area by the New Mexico Environmental Department (NMED) on behalf of the United States Environmental Protection Agency (USEPA) (NMED2011). The data available to Itasca were sufficient to answer the questions posed by Hecla.

2.0 GEOLOGY

2.1 REGIONAL GEOLOGY

The regional geology of the San Juan Basin is shown in Figure 1. The Project Area, the proposed RH permit area, and the former San Mateo Mine are also shown relative to the area depicted. Three structural features associated with the San Juan Basin (the Zuni uplift, Chaco slope, and Rio Grande Rift) are particularly important to the hydrogeology of the Project Area, as discussed below. The Zuni uplift is located approximately 25 to 30 miles southwest of the Project Area. This uplift is an important regional structural feature that exposes rocks as old as Precambrian in age and is an important location of regional recharge to groundwater. The area of transition from the Zuni uplift to the central part of the San Juan Basin is the Chaco slope (Figure 3), where regional sedimentary strata of mainly Mesozoic age dip gently to the northeast, into the central part of the basin. The dip of the rock units varies between four to eight degrees. The Rio Grande Rift is located on the southeast margin of the San Juan Basin and groundwater flow in the southeastern portion of the basin is generally directed toward this regional structural feature (Figure 3).

The stratigraphic column of geologic units encountered regionally is shown in Figure 4 and includes several units, such as the Menefee Formation, Point Lookout Sandstone, and Mount Taylor volcanics, that are not present in the Project Area due to an erosional unconformity.

2.2 SPECIFIC GEOLOGY OF PROJECT AREA

Understanding the geology and stratigraphy of the Project Area in relation to groundwater sampling activities, is critical to evaluating potential water-quality impacts to groundwater in the Project Area. Figure 5 is a stratigraphic column for the Project Area. It is particularly significant for answering two of the questions posed that some of the uppermost formations present regionally are not present in the Project Area, as they have been removed by erosion. Figure 5 also includes the stratigraphic locations of the screened zones for monitoring and domestic wells sampled for groundwater-quality investigations. The Gallup Sandstone is present in the Project Area, and it caps the mesas that occur within and in the vicinity of the Project Area; however, this sandstone is generally not saturated in the Project Area.

2.2.1 Surficial Sediments

In the Project Area, surficial sediments that are classified as alluvium or colluvium range in thickness from 0 to 80 ft. These sediments are typically thin and unsaturated near the mesas and become thicker and saturated near the San Mateo Creek drainage channel (Figure 2), a stream that flows intermittently.

2.2.2 Mancos Shale

As mentioned previously, the Menefee Formation and Point Lookout Sandstone do not exist in the Project Area because they have been eroded. As a result, the main body of the Mancos Shale is below the surficial sediments or the Gallup Sandstone. The Mancos Shale forms a widespread regional aquitard that is approximately 600 to 1,000 ft thick locally. The Mancos Shale represents the interplay of transgressive and regressive episodes of the epicontinental Western Interior Seaway. Shale, mudstone, claystone, and limestone were deposited during transgressions, and sandstones were deposited during regressions (Environmental Sciences Laboratory 2011). The Twowells Sandstone Tongue, an interbed of the Dakota Sandstone, occurs between the main body of the Mancos Shale and the Whitewater Arroyo Tongue of the Mancos Shale. One of the former domestic wells in the Project Area, GMD-04, which is located upgradient of the mine, appears to have been screened in this interbed within the Mancos Shale. Other localized sandstone lenses are also present within the main body of the Mancos Shale. As will be discussed later, the other former domestic well in the Project Area (GMD-05) is probably screened within the Mancos Shale.

2.2.3 Dakota Sandstone

The Dakota Sandstone is located below the Mancos Shale and was deposited during the initial transgression of the seaway, although, as previously noted, there is some interbedding between these formations. The Johnny M Mine potable groundwater-supply well (WW in Tables 1 and 2) was screened in the Dakota Sandstone (Figure 5). The Twowells Sandstone Tongue is the uppermost unit of the Dakota Sandstone and ranges in thickness from about 30 to 120 ft (Roca Honda Resources 2011), with an average thickness of approximately 70 ft. This is the uppermost bedrock water-bearing zone in the Project Area and, based on the depth of GMD-04 (depth to groundwater at 624 ft below top of casing and a total depth of 715 ft bgs), also appears to be the unit in which GMD-04 is screened. Below the Twowells Sandstone is another approximately 50 to 150 ft of Mancos Shale (the Whitewater Arroyo Shale Tongue), and below that is the 20 to 80 ft thick main body of the Dakota Sandstone. Based on the drilling log, well WW appears to be screened in the main body of the Dakota Sandstone (water level at a depth of 673 ft below top of casing and a total depth of 1,084 ft bgs).

2.2.4 Morrison Formation

The Morrison Formation is located below the main body of the Dakota Sandstone. The uppermost portion of the Morrison Formation is the Brushy Basin Member. Excluding the sandstone Poison Canyon Tongue at its base, the Brushy Basin Member is green shale with very low hydraulic conductivity (as evidenced by very slow draindown from the overlying Dakota Sandstone following dewatering of the Morrison Formation sandstones during mining (Rosel 1979)). The Brushy Basin Member averages about 100 ft thick in the local area. As previously mentioned, the Johnny M Mine recovered ore from sandstones in the Morrison Formation, namely the Poison Canyon Tongue, at the base of the Brushy Basin Member, and the subjacent (approximately 25 ft below) Westwater Canyon Member of the Morrison Formation, at depths of approximately 1,300 to 1,400 ft bgs. The mine was backfilled with tailings sand that was slurried into the mine workings in the Morrison Formation, and several water-quality sampling locations discussed below are within this zone (i.e., well 15, well 143, the North Vent pipe, UG4, UG5, UG6, DS2, and DN1; see Table 1; see also Figure 2 for locations of well 15, well 143, and the North Vent pipe).

3.0 HYDROGEOLOGY

3.1 REGIONAL HYDROGEOLOGY

In the San Juan Basin (including the Project Area), there are several thick, very low-permeability shale layers (e.g., the Mancos Shale, Brushy Basin Member of the Morrison Formation, and the Recapture Shale) that hydraulically separate the formations that serve as groundwater resources in the region. These shale layers separate the deeper groundwater resources (i.e., the Gallup Formation, Dakota Sandstone Formation, and Westwater Canyon Member of the Morrison Formation) from each other, as well as from the much shallower alluvial groundwater systems and shallow groundwater resource units (i.e., Point Lookout Sandstone and Menefee Formation) that are present regionally (INTERA 2012). Thus, recharge and discharge associated with these deeper units are a function of their outcrop exposures.

In general, groundwater recharge enters the groundwater-flow system as precipitation on permeable formations that crop out along the southern margin of the San Juan Basin and on the flanks of the Zuni, Chuska, and San Mateo mountains. Groundwater then flows downgradient, either northwestward to discharge along the San Juan River, or in the southeast portion of the basin (where the Project Area is located), northeastward, eastward, and southeastward (see Figure 3) toward the Rio Grande Rift, to discharge to tributaries of the Rio Grande, including the Rio Salado, Rio Puerco, and Rio San Jose. Potentiometric surface maps indicate that the pattern of regional groundwater movement within the deeper units in the southeastern part of the San Juan Basin is greatly influenced by the Zuni uplift, the Chaco slope, and the Rio Grande Rift (Roca Honda Resources 2011).

The movement of groundwater through the alluvial valleys is influenced by topography and surface-water drainages and is independent of—and sometimes flows in directions opposing—groundwater movement in the deep water-bearing units. Volcanic rocks of the Mt. Taylor volcanic field are present less than five miles to the east and south of the Project Area. This is an area of local and regional groundwater recharge for shallower rocks of the Tertiary and Upper Cretaceous age. The younger, shallower groundwater-bearing units in the region (e.g., the Menefee Formation and Point Lookout Sandstone) are not present in the Project Area. Where present regionally, these units occur higher in the stratigraphic sequence. The direction of groundwater flow for the shallow water-bearing unit in the region, the Menefee Formation (Figure 6), is to the northwest. The elevations of the water table (in the Menefee Formation) are approximately 600 to 700 ft above the potentiometric surface of the Westwater Canyon Member (cf. Menefee Formation and Westwater Canyon Member potentiometric contours in Figure 6). The higher potentiometric surface in the Menefee Formation indicates that there is a downward vertical gradient, and the vertical hydraulic gradient may be due, at least in part, to the low permeability of the Mancos Shale that separates alluvium and shallow water-bearing bedrock units from the deeper water-bearing units in the Project Area.

Other important regional water-bearing units, such as the Dakota Sandstone, are substantially deeper, moving away from the Project Area to the northeast. The Dakota Sandstone dips downward at an angle of 350 to 700 ft per mile to the northeast of the Project Area because of the dip associated with the Chaco slope. Accordingly, the geologic units present in the Project Area that could be considered groundwater resources, such as the Dakota Sandstone, are less desirable as a source of groundwater downgradient of the Project Area due to depth and the associated high costs of drilling and pumping water from deep wells. There are no identified domestic or stock wells completed in the Morrison Formation or Dakota Sandstone to the northeast of the Project Area. The distance of this well search is over ten miles from the mine. The nearest domestic wells in the general downgradient direction of the Project Area (wells 4, 7, 132, and 133 in Figure 7) are screened in the much shallower Menefee Formation or Point Lookout Sandstone. These wells are at least four miles northeast of the Project Area (Figure 7); furthermore, the hydraulic gradient in the vicinity of the Project Area is downward, away from the units in which these wells are screened. Figure 3 shows the basin-wide general regional pattern of deep groundwater flow in the Jurassic (Morrison Formation) and Cretaceous (Dakota Sandstone) water-bearing units (relevant to the Project Area) and Figure 8 shows the potentiometric surface and groundwater flow directions specific for the Westwater Canyon Member of the Morrison Formation in the southeastern portion of the San Juan Basin. As noted in Figures 3 and 8, groundwater flow in the deep Dakota Sandstone and Morrison formations is to the east-southeast based upon a regional analysis. Figure 6 shows that in the vicinity of the Project Area, deep groundwater flows to the northeast.

3.2 SPECIFIC HYDROGEOLOGY OF THE PROJECT AREA

3.2.1 Shallow Groundwater (Surficial Sediments)

Groundwater flow within the surficial sediments (alluvium and colluvium) that are located on the slopes and within the alluvial valleys follows the local topography (flow in the alluvium within the Project Area is generally to the west/southwest) in the opposite direction of groundwater flow in the bedrock (to the east/northeast). The alluvium is a source of groundwater to wells that are located near the San Mateo Creek drainage channel. The creek is also a source of groundwater recharge.

During mining operations, treated mine water was discharged from the ponds to a ditch and later to a pipe that eventually emptied into the San Mateo Creek drainage channel. A portion of this water, along with precipitation runoff, infiltrated these alluvial sediments and flowed to the San Mateo Creek drainage channel. Later, the pond water was piped farther down the slope, discharging at or near the San Mateo Creek drainage channel. Discharged water that infiltrated the surficial sediments would have perched on top of the Mancos Shale forming a saturated zone within the shallow surficial sediments; monitoring wells GW7, GW8, GW8A, and GW9 were installed and screened at the contact between the surficial sediments and the Mancos Shale (Figure 5) to monitor groundwater quality at this contact in response to discharges from the surface treatment ponds.

3.2.2 Intermediate Groundwater (Mancos Shale)

The hydraulic conductivity in the Mancos Shale is generally very low, on the order of 5×10^{-8} cm/s (Roca Honda Resources 2011). To put this value into context, a compacted clay liner for a municipal landfill typically has a permeability (hydraulic conductivity) of approximately 1×10^{-7} cm/s (Benson and Trast 1995). Isolated sandstone lenses typically occur within the Mancos Shale (Environmental Sciences Laboratory 2011) and have been noted in drill logs from the Project Area. For example, 'gray sandstone' was noted in the geologic log at 115 to 130 ft bgs from a former domestic well within the Project Area located upgradient of the mine (OSE#B-01544, subsequently identified as GMD-04) within the 615 ft thick Mancos Shale interval. The well log for the other well at the former residence located upgradient of the mine, GMD-05, was not available for evaluation. It was noted though that GMD-04 was drilled as a replacement because

GMD-05 failed to produce water at sufficient rates (T. Jackson, pers. comm. with M. Schierman of ERG). As discussed below, the quality of groundwater from GMD-05 also appears similar to that reported elsewhere for the natural groundwater quality associated with the Mancos Shale.

3.2.3 Deep Groundwater (Dakota Sandstone and Morrison Formation)

The hydraulic conductivity of the Dakota Sandstone ranges from 9×10^{-5} to 5×10^{-4} cm/s (INTERA 2012). The hydraulic conductivity values for the Dakota Sandstone suggest that it is capable of transmitting low to moderate volumes of water depending on its thickness. Wells producing from the Dakota Sandstone yield in the range of 1 to 75 gpm with a median value of 12 gpm (Roca Honda Resources 2011).

The hydraulic conductivity of the Westwater Canyon Member varies from 7×10^{-6} to 6×10^{-4} cm/s (INTERA 2012). These values suggest that the Westwater Canyon Member transmits low to relatively high quantities of water, again, depending on its thickness. Wells completed in the Westwater Canyon Member have been pumped at rates between 10 and 560 gpm with typical values around 100 gpm (Roca Honda Resources 2011). As noted in Figure 6, the direction of flow for groundwater in the Project Area in the Westwater Canyon Member is towards the north-northeast.

The hydraulic gradient calculated from the potentiometric surface map for the Westwater Canyon Member shown in Figure 6 is approximately 0.024 ft/ft to the northeast. Assuming an effective porosity of 0.1 (Roca Honda Resources 2011) yields a range of groundwater velocities of 2 to 150 ft per year in the Westwater Canyon Member. Based upon this range of values, it would take groundwater approximately 35 to 2,600 years to travel one mile. Assuming the hydraulic gradient of 0.024 ft/ft, the elevation of the potentiometric surface would be at an elevation of approximately 5,350 ft above mean sea level in the vicinity of well 133 (Figure 7), a well screened in the Menefee Formation. The elevation of the bottom of this well is approximately 6,760 ft (Roca Honda Resources 2011). This means that there is approximately 1,200 ft of separation between groundwater in the Morrison Formation and the Menefee Formation.

4.0 GROUNDWATER QUALITY

The available groundwater-quality data related to the Project Area were compiled by Itasca and are provided in Table 2 and discussed below.

The assessment of potential past and future groundwater impacts resulting from historical mining operations hinges on the potential migration of uranium (U) in groundwater. The following paragraphs provide an overview of the geochemistry of U and its potential to migrate in groundwater.

Uranium movement in groundwater is dependent upon the geochemical conditions of the environment, particularly with respect to pH and oxidation state (i.e., Eh). Uranium in an oxidizing environment is capable of migrating with groundwater, unlike in reducing conditions such as those found in groundwater in the Dakota Sandstone and Morrison Formation in the Project Area. Figure 9 shows an Eh-pH diagram for the simplified geochemical system composed of U, silica, and water at 25°C. Minerals such as coffinite ($USiO_4$) illustrated in Figure 9 and uraninite [UO_2(a)]—which occupies a similar but smaller stability range to that illustrated for coffinite in Figure 9—contain U in its reduced form, the U(IV) valence state, and are relatively insoluble and stable under reducing conditions. Whereas, the mineral schoepite [$UO_2(OH)_2 \bullet H_2O$] (Figure 9) contains U in the U(VI) valence state. The U(VI) valence state is predominant in more oxidizing conditions, such as those frequently associated with surface water and shallow groundwater. It is often present as a UO_2^{+2} ion or associated hydroxide and/or carbonate complexes. Unlike the U(IV) valence state that is predominant in more reducing conditions, the uranyl hydroxide and/or carbonate complexes can increase U migration in groundwater relative to U(IV). Furthermore, the mineral schoepite, which forms in more oxidizing conditions, is more soluble than the minerals coffinite and uraninite that form under more reducing conditions. Accordingly, the solubility of U minerals also contributes to the ability of U to migrate in oxidizing conditions typically associated with surface water and shallow groundwater.

Radium is generally not of concern in the Project Area based upon work conducted by the NMED (NMED 2010). The NMED indicated in a review of geochemistry in the San Mateo Creek (SMC) area that:

> [Radium] Ra does not appear to be a contaminant of concern in the ground water system of the SMC study area because it is relatively insoluble, does not tend to form soluble complexes with other ions, was easily precipitated out of acidic mill tailings by the addition of $BaSO_4$, and has a strong tendency to adsorb onto various mineral surfaces such as clays and other silicate minerals (Landa, 1980). Based on the water sample results from EPA, 1975, and the results from this investigation, Ra does not appear to be a radiochemical of concern or a reliable indicator of legacy U mining and milling impacts.
>
> In contrast, U concentrations from this investigation indicate that this radionuclide is elevated in the ground water, and the geochemical conditions support transport of this metal in the aqueous environment.[1, 2]

The NMED (2010) concluded that the estimated average U concentration in groundwater samples that are assumed not to be impacted by mining or milling discharges is less than 5 µg/L.

4.1 SHALLOW GROUNDWATER QUALITY

4.1.1 Shallow Groundwater-Quality Observations

Shallow groundwater, when present, is separated from the deeper Dakota Sandstone Formation and Morrison Formation water-bearing zones by more than 600 ft of relatively impermeable (Mancos) shale. Hence, the mining activities in the Project Area with the potential to have affected the quality of shallow groundwater were the surface activities associated with discharging mine water into the ponds/ditch and the potential for leaching of stockpiled mine-related materials on the land surface.

During infiltration events in the Project Area, surface water infiltrates downward and perches temporarily on the bedrock (Mancos Shale) surface before it moves downgradient.

Potential degradation of shallow groundwater from the above activities is evaluated below by comparison of the water quality associated with dewatering water, sand slurry, shallow

[1] Note that $BaCl_2$ was used for water-quality treatment at the Johnny M Mine. This forms an insoluble $BaSO_4$ co-precipitate that quantitatively removes radium.

[2] The NMED text cited here is in reference to surficial, oxidizing conditions. Uranium is much less soluble and mobile under reducing conditions, such as those in the Johnny M Mine following inundation by groundwater at the end of mining.

groundwater monitoring wells, and well(s) located on a nearby ranch. As illustrated in Figure 5, the shallow groundwater monitoring wells located within the Project Area were typically constructed to collect water from the contact between the surficial sediments and the top (weathered surface) of the Mancos Shale. Weathered zones of the Mancos Shale have been noted as being naturally affected by geochemical processes including pyrite oxidation, carbonate dissolution, gypsum precipitation, release of nitrate from weathering of organic material, and solubilization of U (Environmental Sciences Laboratory 2011). Consistent with these processes, Figure 10 illustrates that the sulfate concentrations observed in the shallow groundwater monitoring wells (GW7, GW8A, and GW9) are actually higher, in most cases, than the concentrations observed in sand slurry (MWS-3), dewatering discharge, and MW-1 (which was the monitoring location for discharge from the pipeline or ponds prior to entry into the San Mateo Creek drainage channel), or any of the water-quality samples collected from within the underground mine (e.g., DN1, DS2, UG4, UG5, UG6, North Vent pipe).

Similarly, Figure 11 illustrates the nitrate and U concentrations from shallow groundwater wells, the upgradient wells (former domestic wells) within the Project Area, sand slurry, and various mine-water samples. The shallow groundwater-well samples generally cluster around the U and nitrate geometric mean for the Mancos Shale, but with slightly lower U concentrations. In contrast, U concentrations in mine waters are typically an order of magnitude higher than those observed in the shallow groundwater monitoring wells, and the nitrate concentrations are typically one to three orders of magnitude lower in mine waters than in the shallow groundwater monitoring wells.

Water chemistry was measured in 1993 in a groundwater sample from a well located on the Marcus Ranch, which is a shallow groundwater well located on the north side of the San Mateo Creek drainage channel and downgradient of the former Johnny M Mine discharge location (Figure 2). The gross alpha concentration (activity) was 6±15 pCi/L, the ^{226}Ra concentration was 0.20±0.28 pCi/L, the gross beta concentration (activity) was 7±29 pCi/L, the dissolved U was 3.5 µg/L, arsenic was less than 0.005 µg/L, lead was less than 0.01 µg/L, molybdenum was less than 0.02 µg/L, selenium was less than 0.01 µg/L, and vanadium was less than 0.01 µg/L. In summary, concentrations of U, ^{226}Ra, arsenic, lead, molybdenum, selenium, and vanadium were either below detection limits or below drinking water-quality standards (Science Applications International Corporation 1994).

4.1.2 Conclusions Regarding Potential Impacts to Shallow Groundwater Quality

Mining-related discharge water that infiltrated the shallow surficial sediments and perched on the surface of the Mancos Shale more than 25 years ago as a result of mining activities would not now be contributing seepage to the San Mateo Creek drainage system. Subsequent overland runoff and infiltration over the past 25 years would have concentrated in drainage features and tended to 'flush' sediments. Given that the runoff waters would be rich in dissolved oxygen, this oxygenated water would have mobilized any U, or 'flushed' any U from the sediments.

The groundwater quality measured in a water sample from the Marcus Ranch well indicated that the water-bearing surficial sediments have not been impacted by the historical discharges from the mine or by the current conditions within the Project Area. Whereas the other radionuclides (alpha and gross beta) had large errors surrounding the measured concentrations, the reported concentrations do not indicate impacts, particularly when considered together with the low concentrations of U, ^{226}Ra, and other metals typically associated with mine water.

4.2 INTERMEDIATE GROUNDWATER QUALITY

4.2.1 Intermediate Groundwater-Quality Observations

The groundwater-quality compositions of the two upgradient wells (former domestic wells) within the Project Area (GMD-04 and GMD-05) are quite different from one another. The results of groundwater analyses for wells GMD-04 and GMD-05 are shown in Table 2. The quality of groundwater from GMD-04 can be summarized as follows:

- a mixed calcium/sodium-bicarbonate/sulfate water type;
- at or near the USEPA human health-based maximum contaminant limit (MCL)[3] for gross alpha (17.3±4.01 picocuries per liter (pCi/L) vs. MCL of 15 pCi/L); there is no applicable State standard[4] for gross alpha for groundwater;
- at or near the MCL for radium radioactivity (3.33±1.15 pCi/L for ^{226}Ra plus 2.67±0.75 pCi/L for ^{228}Ra vs. MCL of 6.0 pCi/L combined), although this is substantially less than the applicable State standard of 30 pCi/L for radium in groundwater;

[3] USEPA primary MCL (includes both safety factors and lifetime exposure scenarios) and secondary MCL (addressing aesthetic quality) values.
[4] State standards for groundwater are the New Mexico Water Quality Control Commission (NMWQCC) standards, which are applicable to domestic water supply.

- exceeds the secondary MCL for manganese (68.1 micrograms per liter (µg/L) vs. secondary MCL of 50 µg/L); there is no applicable State standard for manganese in groundwater;
- exceeds the secondary MCL for sulfate (270 milligram per liter (mg/L) vs. secondary MCL of 250 mg/L); although this is substantially less than the applicable State standard of 600 mg/L for sulfate in groundwater; and
- exceeds the secondary MCL for total dissolved solids (TDS) (709 mg/L vs. secondary MCL of 500 mg/L); although this is substantially less than the applicable State standard of 1,000 mg/L for TDS in groundwater.

In summary, GMD-04 exceeds secondary MCL values for manganese, sulfate, and TDS and the primary standard for gross alpha.

In comparison, the groundwater quality from well GMD-05 can be summarized as follows:

- a sodium-chloride water type;
- exceeds the secondary MCL and State standard for chloride in groundwater (1,500 mg/L vs. secondary MCL and State standard of 250 mg/L);
- exceeds the secondary MCL for sulfate (280 mg/L vs. secondary MCL of 250 mg/L), although this is substantially less than the State standard of 600 mg/L for sulfate in groundwater; and
- exceeds the secondary MCL and State standard for TDS in groundwater (3,070 mg/L vs. secondary MCL of 500 mg/L and State standard of 1,000 mg/L).

In summary, GMD-05 exceeds applicable secondary MCL and State groundwater-quality standards for chloride and TDS. As previously mentioned, this well does not produce sufficient rates of water flow for use as a domestic well.

As noted previously, well GMD-04 appears to be screened in the upper portion of the Dakota Sandstone (the Twowells Sandstone Tongue). The water quality of the Dakota Sandstone was characterized in the Marquez, New Mexico area by Daniel B. Stephens and Associates, Inc. (DBSA 2008), who provided the following description:

> The Dakota Sandstone is a sodium-bicarbonate water type near recharge areas with increasing sulfate concentrations downgradient (Dam 1995). Water quality in the Dakota Sandstone is variable and generally acceptable for domestic, livestock, and industrial use (Dam 1995). In some areas the

groundwater has elevated TDS and sulfate concentrations that exceed standards (Table 4). Trace elements that were detected at concentrations above standards include iron and manganese (Table 5).

The TDS, sulfate, and manganese water quality exceedances reported for the Dakota Sandstone are consistent with the groundwater quality observed in GMD-04. Gross alpha and radium radioactivity were not reported by DBSA for the Dakota Sandstone; however, the Dakota Sandstone has been reported as a host for low grade U deposits in the Grants Mineral Belt (Green 1980). In fact, U concentrations in the Dakota Sandstone measured in the Johnny M Mine water well in January 1973, prior to the initial mine shaft reaching the ore zone, were 340 µg/L, which would typically equate to a gross alpha of more than 200 pCi/L.

The chemistry of groundwater samples from GMD-05 is generally consistent with background groundwater quality in the Mancos Shale. Figure 10 illustrates the chloride and sulfate concentrations for groundwater samples from GMD-04 and GMD-05, the ranges (minimum, maximum, and geometric mean) observed in water samples from the Mancos Shale regionally (Environmental Sciences Laboratory 2011), and from groundwater, surface water (e.g., MW-1 in Table 2), and mine water collected in the Project Area. Note that the chloride concentrations (which, together with sodium comprise the majority of the dissolved constituents) in GMD-05 are higher than for any of the other waters in the Project Area and this well is located vertically and laterally upgradient of the former Johnny M Mine. Of the water-quality samples included in Figure 10, only groundwater from the Mancos Shale (regionally) has chloride concentrations as high as those observed in GMD-05. There is a lower proportion of sulfate relative to chloride observed in GMD-05 (in comparison with the Mancos-Shale trend), which could be an artifact of locally reducing conditions (that would also account for the low dissolved U and metals in water from this well), or could be a result of limited availability of deeper-water samples from the Mancos Shale (because groundwater wells are not typically completed in the Mancos Shale). However, it has been noted that groundwater from deep (greater than 27 m below ground surface) wells in the Mancos Shale have "a sodium chloride composition, in stark contrast to the sulfate-dominated water in shallow, more weathered horizons" (Morrison et al. 2012).

4.2.2 Conclusions Regarding Potential Impacts to Intermediate Groundwater Quality

Uranium concentrations in GMD-04 and GMD-05 are 3 µg/L and <2 µg/L, respectively, as presented in Section 4.0, which, as noted previously, are not indicative of mining-related impacts (NMED 2010).

The horizontal hydraulic gradients within the Dakota Sandstone and Morrison Formation are northeastward/eastward, away from the Project Area so that potential water-quality impacts within the Dakota Sandstone and lower units would migrate away from the former domestic wells in the Project Area. Lastly, approximately 600 ft of relatively impermeable shale (Mancos Shale) separates former surface operations from the screened interval of GMD-04. The groundwater quality observed in GMD-04 is consistent with naturally occurring conditions in the Dakota Sandstone and is not indicative of legacy U mining impacts.

Impacts from mine water cannot account for the groundwater quality observed in well GMD-05 because this well is upgradient of the Morrison Formation and Dakota Sandstone groundwaters in the Project Area, and water from this well has higher concentrations of chloride than any of the mine waters. Well GMD-05 appears to be representative of naturally occurring poor groundwater quality in a geologic unit of low transmissivity, most likely the Mancos Shale. The groundwater quality of these upgradient wells (former domestic wells) within the Project Area is unrelated to mining activity; therefore, the water-quality analysis from these wells should not be used for evaluating the question of whether shallow groundwater quality in the Project Area is impacted as a result of past mining activities.

4.3 DEEP GROUNDWATER QUALITY

4.3.1 Deep Groundwater-Quality Observations

Water quality in the underground workings at the Johnny M Mine was monitored prior to and during backfilling with a sand slurry that started in August of 1977 and was completed sometime prior to cessation of mining activity in 1982.

Figure 12 illustrates the water quality of various groundwater, mine-water, and surface-water samples compiled from various sources (see also Table 2). The actual water-quality parameters analyzed differ somewhat between sampling events due to the differing objectives of the various sampling events. The earliest data illustrated in Figure 12 are groundwater samples from the Dakota Sandstone during development of the initial mine shaft prior to any ore mining. There are numerous sampling data during backfill placement. In terms of subsequent monitoring, a sample was collected from the North Vent pipe in 1985, and the NMED conducted sampling of the upgradient former domestic wells in the Project Area. The North Vent pipe is a sampling point at the former ventilation shaft of the Johnny M Mine used to sample groundwater quality in the backfilled mine (Westwater Canyon Member). Additional sampling of the groundwater quality in the Morrison Formation that hosts the backfilled underground workings (e.g., wells 15 and 143) has recently been conducted as part of baseline water-quality evaluations being conducted for the proposed Roca Honda Project (Roca Honda Resources 2011). The North Vent pipe, well 15, and well 143 draw groundwater from the Westwater Canyon Member of the Morrison Formation.

As illustrated in Figure 12, the sand-slurry water (MSW-3) had elevated concentrations of various constituents (i.e., arsenic, nitrate, molybdenum, selenium, vanadium, gross alpha, radium, thorium, U, chloride, sulfate, and TDS) as compared to the other water samples. Water samples were collected 26 times at location MSW-3 from September 1977 to December 1978 (Table 2). Although the sand-slurry water contained notably elevated concentrations of some water-quality constituents, that water was removed from the mine after the backfill was deposited. Mine-water samples illustrated a much smaller and temporary increase in some constituents during and/or immediately following backfill placement, but the subsequent analyses of water quality within and near the mine (North Vent pipe, well 15, and well 143) all indicate that the groundwater quality in the Morrison Formation has since returned to background concentrations as represented by analyses of groundwater samples from the aforementioned locations. The concentrations of these constituents observed in the underground workings were much lower as a result of immobilization under the circumneutral and reducing conditions of ambient groundwater. On the other hand, the slurry water was initially oxidizing and in some cases mildly acidic. In addition, the slurry water was pumped from the mine, treated, and discharged.

The 1985 sample from the North Vent pipe indicated the following concentrations in groundwater at a depth within the backfilled mine: arsenic was 0.011 mg/L; molybdenum was 0.3 mg/L; selenium was <0.005 mg/L; vanadium was <0.1 mg/L; chloride was 11.9 mg/L; sulfate was 205 mg/L, TDS was 495 mg/L; and nitrate, gross alpha, radium, thorium, and U were not reported. The water-quality parameters measured either met water-quality standards that existed at the time or reflected natural groundwater conditions.

In the most recent sampling event for well 143 (September 23, 2010), all constituents either meet USEPA public drinking water system standards or are similar to background concentrations. Specifically, arsenic, nitrate, selenium, molybdenum, and vanadium are all below limits of detection; gross alpha radiation is 6 pCi/L, radium (226 plus 228) is 4.9 pCi/L, thorium (230) is 0.5 pCi/L, and U is 3.2 µg/L, chloride is 18 mg/L, sulfate is 276 mg/L, and TDS is 737 mg/L. For comparison, the geometric mean of sulfate and TDS concentrations in the Westwater Canyon Member of the Morrison Formation (based on 48 samples from the nearby area) is 425 and 1,047 mg/L, respectively (Roca Honda Resources 2011).

Similarly, recent sampling events for well 15 indicated that all of these constituents meet USEPA public drinking water system standards. Specifically, arsenic, nitrate (with the exception of one sample reported at the detection limit of 0.1 mg/L), selenium, molybdenum, vanadium, and U are all below detection; gross alpha radiation is less than or equal to 3.4 pCi/L, radium (226 plus 228) is less than or equal to 1.62 pCi/L, thorium (230) is less than 0.2 pCi/L, chloride is less than or equal to 9 mg/L, sulfate is less than or equal to 181 mg/L, and TDS is less than or equal to 591 mg/L. Well 15 is located east of the former Johnny M Mine and, for deeper groundwater, could represent a downgradient sampling point from the mine.

4.3.2 <u>Conclusions Regarding Potential Impacts to Deep Groundwater Quality</u>

Backfilled sand that was placed into the Johnny M Mine are unlikely to impact deep groundwater quality because

1) the slurry water was removed from the mine immediately following placement of the backfill, and

2) the materials used (or considered for use) in backfilling operations in the Grants Mineral Belt (Thomson and Heggen 1982; Thomson et al. 1986), and at Johnny M Mine specifically (Gamble 1992), were largely devoid of the finer particles (e.g., clays) that carry the majority of the leachable/reactive metal content (Thomson and Heggen 1982; Thomson et al. 1986).

Removal of the fine material (e.g., clay) was an important consideration in the use of the sand for placement. Sand was used as backfill material because it was easier to transport and to handle within the mine. Also, the use of sand as backfill was driven by safety concerns, i.e., 'unsized tailings' material would not drain properly and could cause a potentially dangerous 'muck rush' condition within the mine. The finer particles (e.g., clays), less than 200 mesh, contained the majority of the leachable reactive load (Thomson et al. 1986), and this material was retained at the Ambrosia Lake mill and tailings facility. These facilities were not located in the Project Area. Thus, the removal of the fines (e.g., clay) substantially reduced the amount of leachable constituents, including metals, the metalloids such as arsenic (As) and selenium (Se), and sulfate (SO_4). Analyses described in Thomson et al. (1986), and summarized in Thomson's Tables 3 and 4 (see below), indicate the difference in compositions for the sand and clay fractions from undisclosed operations in the Grants Mineral Belt. The tables show that large enrichment factors are present, with the fine (e.g., clay) fraction always showing enrichment relative to the sand fraction.

Table 3. Average concentrations in each fraction of backfilled sands, determined by INAA (9 samples)

Element	Sand (ppm)	Clay (ppm)	Water* (mg/l)	Enrichment Clay/Sand
Al	35633.3	66800.0	3.3	1.9
As	3.16	18.47	0.12	5.8
Ba	695.8	945.8	0.0	1.4
Ca	2362.2	32887.8	323.9	13.9
Cr	10.4	317.9	0.2	30.7
Fe	2081.6	25994.4	7.8	12.5
K	22366.7	25855.6	228.5	1.2
Mg	0.0	3173.3	0.0	17.5
Mo	10.2	178.6	0.3	17.5
Se	8.24	80.31	0.90	9.8
Th-223	1.828	7.513	0.002	4.1
U-239	29.27	226.41	0.70	7.7
V	82.4	928.8	0.6	11.3

* Concentrations in 250 ml of solution containing 100 g of backfilled sands.

Table 4. Average concentrations in each fraction of acid-leach uranium. mill tailings by INAA (2 samples)

Element	Sand (ppm)	Clay (ppm)	Water* (mg/l)	Enrichment Clay/Sand
Al	37850.0	60050.0	0.0	1.6
As	2.51	20.44	0.17	8.2
Ba	778.5	642.0	0.0	0.8
Ca	2775.0	41150.0	470.1	14.8
Cr	9.88	157.30	0.0	15.9
Fe	2387.5	30370.00	11.5	12.7
K	23500.0	25400.0	64.9	1.1
Mg	0.0	2650.0	0.0	
Mo	5.39	216.00	0.0	40.1
Se	8.17	124.10	0.13	15.2
Th-223	1.172	2.488	0.0	2.1
U-239	19.04	118.35	0.10	6.2
V	169.45	954.00	0.69	5.6

* Concentrations in 250 ml of solution containing 100 g of acid-leach uranium mill tailings.

Note: Tables 3 and 4 were copied directly from the original peer-reviewed paper. However, the Th-223 values reported may actually represent Th-233, which is derived from neutron activation of Th-232 (used in instrumental neutron activation analysis [INAA]).

In addition to the fact that sand, rather than fines, was utilized in backfilling, the geochemical conditions in the backfilled mine act to limit solubility and thus the potential for metals migration.

Over the last 15 to 20 years, subaqueous disposal of tailings has been employed at numerous mining operations to limit the formation of acid-rock drainage and the subsequent leaching of metals. The mitigation of acid and metals leaching by subaqueous disposal is due to the slow rate of diffusion of oxygen through water relative to air; a water cover is used primarily to halt pyrite oxidation and subsequent acid-rock drainage in the near surface (MEND 2001). Molecular oxygen is the primary driver for oxidation reactions involving pyrite (FeS_2). Upon the cessation of dewatering, groundwater collecting in the Johnny M Mine would behave similarly, with backfilled sand and other minerals in the mine environment stabilized by the reducing conditions. Limited access of oxygen and the presence of organic matter (mainly humic materials present in the Westwater Canyon Member), which would consume any small amounts of residual oxygen, produces a reducing environment (low Eh) that would stabilize U and other constituents as mineral solids, immobilizing them in the deep groundwater system.

For example, the insoluble minerals uraninite and coffinite are stable under reducing conditions (Figure 9), where the presence of electrons donors, such as humic substances, result in low Eh values. Furthermore, the U^{+4} ion that is predominant in these conditions does not have a strong tendency to form aqueous complexes that could increase the concentration of U in solution; rather, the U^{+4} ion tends to form mineral precipitates such as uraninite or coffinite.

The geochemical conditions in the mine after mining was completed and the mine became resaturated are expected to have returned to conditions similar to those that were present prior to mining (i.e., reducing conditions that were responsible for the precipitation of the U(IV) minerals that formed the original ore deposit). These reducing conditions have re-stabilized elements, such as U, that were associated with the ore deposit or backfilled sand. The Johnny M deposit formed under reducing conditions in sediments that were rich in humic materials (derived from plant matter) that allowed for the precipitation of U, which was introduced by periodic volcanic episodes (Falkowski 1980). Thus the distribution of U was influenced directly by the volcanic episodes. It is expected that without exposure to atmospheric oxygen, humic material and other organic matter still present in the geologic materials near the mine, together with reduced minerals such as authigenic pyrite (FeS_2) and jordisite (MoS_2), will continue to support a low Eh environment in and near the mine workings. Dissolved U will precipitate either as coffinite or as uraninite, thus limiting both concentrations and mobility in groundwater.

Redox conditions that limit U mobility are consistent with studies in the general area and with groundwater quality observations in the Project Area. Thomson and Heggen (1982) discuss several redox related processes and estimate the native groundwater to be within a pH range of 6 to 8, with a maximum Eh of approximately 0.17 volts (at a pH of 6), and a minimum Eh of approximately -0.12 volts (pH 8). In Thomson et al. (1986) the authors showed an ore zone region that suggested even lower Eh conditions are possible. These ore zone conditions have Eh values as low as -0.28 volts. These lower conditions are near the boundary between 'organic' carbon and inorganic carbon. This region is also within the boundary between sulfide and sulfate. In addition to the abundant humic materials, the ore zones also contain authigenic (formed in place) pyrite (Falkowski 1980), which will drive redox conditions toward an ore-formation or pre-mining Eh. As discussed below, these organic and sulfide rich, low Eh conditions in the backfilled and saturated Johnny M Mine are apparent from the notable decreases in concentrations of elements such as arsenic, radium, selenium, thorium, U, and vanadium that have occurred subsequent to cessation of dewatering activities in 1982 (Figure 12). The assumptions used by Thomson et al. (1986) to define the Eh-pH region of the Morrison Formation subsequent to mining appear to be a reasonable and appropriate representation for groundwater in the ore zones in the Project Area. Accordingly, under reducing conditions, such as in the deep groundwater in the Dakota Sandstone and Morrison Formation at the Johnny M Mine, U is relatively immobile and has low aqueous concentrations.

In summary, there is no indication that the mine activities have negatively affected groundwater quality in or downgradient of the underground workings at the Johnny M Mine. Water quality at Johnny M Mine and other backfilled underground U mines in the Grants Mineral Belt are similar to their mine water quality prior to backfilling. At the Johnny M Mine, the nearby groundwater wells that provided water samples from depths similar to the mine workings (e.g., wells 15 and 143, and the North Vent pipe) have solute concentrations similar to background conditions. These results are consistent with expected U geochemistry; U is mobile in surficial, oxidizing conditions, but is immobile in the reducing conditions present within the Dakota Sandstone and Morrison Formation in the Project Area.

5.0 SUMMARY AND CONCLUSIONS

Itasca was asked by Hecla Limited to analyze existing hydrogeologic data relevant to conditions at the former Johnny M uranium mine that is located in McKinley County, in northwestern New Mexico. The former mine is located within a historic uranium mining district referenced as the Ambrosia Lake uranium mining district. Mining of ore occurred at the Johnny M Mine from approximately 1976 until 1982 when operations ceased.

Hecla Limited had the following questions that Itasca was to address in its analysis:

- Question 1: Is shallow groundwater quality in the Project Area affected by mine water during operations or leaching from mined materials?
- Question 2: Has the groundwater quality of the former domestic wells in the Project Area (GMD-04 and/or GMD-05) or other groundwater resources been affected by mining-related activity in the Project Area?
- Question 3: Is the quality of groundwater in the Project Area affected by the presence of backfilled tailing sand in the underground workings?

Itasca reviewed the analyses of mine-water, groundwater, and surface-water samples collected during and immediately after mining, as well as samples collected recently by NMED and other contractors working in the nearby area. In addition, a significant amount of data regarding the geology, hydrogeology, and geochemistry of the area surrounding the former Johnny M Mine are available from the Baseline Data Report and other reports generated by or for the proposed Roca Honda Mine that is located approximately one mile east of the former Johnny M Mine.

Based upon Itasca's review and analysis of the existing data, Itasca offers the following conclusions.

Answer to Question 1

Shallow groundwater quality was measured historically in three former groundwater monitoring wells that were located downgradient of the mine-water discharge pathway through the ditch and upgradient of the San Mateo Creek drainage channel. The shallow groundwater monitoring wells were located and screened to collect groundwater samples from the contact between the surficial sediments and the top (weathered surface) of the Mancos Shale. Weathered zones of the Mancos

Shale have been noted as being naturally affected by geochemical processes, including pyrite oxidation, carbonate dissolution, gypsum precipitation, release of nitrate from weathering of organic material, and solubilization of U. Consistent with these processes, the sulfate concentrations observed in the shallow groundwater monitoring wells (GW7, GW8A, and GW9) were actually higher than the concentrations observed in sand slurry water, dewatering discharge or any of the water-quality samples collected from within the underground mine. The shallow groundwater well samples generally cluster around the U and nitrate geometric mean for the Mancos Shale, but with slightly lower U concentrations. In contrast, U concentrations in discharged (treated) mine waters were typically an order of magnitude higher than those observed in the shallow groundwater monitoring wells, and the nitrate concentrations were typically one to three orders of magnitude lower in discharged (treated) mine waters than in the shallow groundwater monitoring wells.

In addition to having groundwater quality that was substantially poorer due to natural conditions (e.g., higher concentrations of sulfate, nitrate, chloride, and TDS) than that associated with mine activities, the shallow groundwater system is transient. During infiltration events, surface water will infiltrate downward and perch on the bedrock (Mancos Shale) surface temporarily. However, the surficial sediments are typically unsaturated and the Mancos Shale is an aquitard. There is no indication that any water that infiltrated the shallow surficial sediments and temporarily ponded on the surface of the Mancos Shale as a result of mining activities more than 25 years ago is contributing seepage to the San Mateo Creek drainage channel or to underlying water-bearing units today. Subsequent overland runoff over the past 25 years would have concentrated in the ditch and tended to have 'flushed' any surficial sediments. Given that the runoff waters would probably be rich in dissolved oxygen, this oxygenated water would have mobilized U, or 'flushed' any U from the surficial sediments.

Water chemistry measured in a shallow groundwater well located on the north side of the San Mateo Creek drainage channel and downgradient of the former Johnny M Mine discharge location (Marcus Ranch well) indicated that the water-bearing surficial sediments have not been impacted by the historical discharges from the mine or by the current conditions within the Project Area. Concentrations of U, ^{226}Ra, arsenic, lead, molybdenum, selenium, and vanadium were either below detection limits or below drinking water standards. Whereas the other radionuclides (alpha and gross beta) had large errors surrounding the measured concentrations, the reported concentrations do not indicate impacts, particularly when considered together with the low concentrations of U, ^{226}Ra, and other metals typically associated with mine water.

Answer to Question 2

The former domestic wells in the Project Area are located upgradient of the former Johnny M Mine (and associated mining activities) and are screened at intermediate depths, either within an upper interbed of the Dakota Sandstone Formation (GMD-04) or within the Mancos Shale (GMD-05). The quality of the groundwater samples collected from these wells is reflective of natural background conditions encountered in these two formations. The groundwater quality observed in well GMD-04 is consistent with naturally occurring conditions in the Dakota Sandstone and is inconsistent with legacy U mining impacts. The groundwater quality observed in well GMD-05 appears to be representative of naturally occurring poor groundwater quality in a low transmissivity geologic unit, most likely the Mancos Shale. Impacts from mine water cannot account for the groundwater quality observed in wells GMD-04 and GMD-05. This is especially applicable for well GMD-05 as this well is upgradient of the mine (both vertically and laterally), and the water in this well has higher chloride concentrations than any of the mine waters.

These wells are also hydraulically separated from shallow groundwater that may have been impacted in the past from mine water discharges to the land surface via a ditch or from a pipe by more than 600 ft of Mancos Shale that has a hydraulic conductivity of approximately 5×10^{-8} cm/sec, a value lower than compacted clay liners used in landfills.

Other geologic units used as potential groundwater resources such as the Menefee Formation and Point Lookout Sandstone do not exist in the Project Area because they have been eroded. The nearest wells that are screened in these two formations are more than four miles to the northeast which is downgradient of the Project Area, due to the regional dip of the geologic units. The potentiometric surface of the Morrison Formation is estimated to be more than 1,200 ft below a well screened in the Menefee Formation. Given this large vertical separation and the fact that there is a downward gradient, water quality in the Morrison Formation or the Dakota Sandstone is not expected to impact these shallower geologic units.

The regional dip of the geologic units and the groundwater flow direction within the Dakota Sandstone and the Morrison Formation are towards the northeast. There are no domestic or stock wells completed in these formations to the northeast of the mine. These two formations are not used for groundwater supply northeast of the mine because the depths of these formations increase due to the regional dip, thus making drilling to these units and pumping groundwater uneconomical.

In summary, there is no evidence that the former mine is currently having an impact on groundwater quality—either at the upgradient former domestic wells in the Project Area or elsewhere.

Answer to Question 3

Subaqueous disposal of tailings has been employed at numerous mining operations to limit the formation of acid-rock drainage and the subsequent leaching of metals. This is because of the slow rate of diffusion of oxygen through water. A water cover is used primarily to halt pyrite oxidation and subsequent acid-rock drainage in the near surface. Molecular oxygen is the primary driver for oxidation reactions involving pyrite (FeS_2). Similarly, limiting oxygen to U(IV) bearing minerals such as coffinite ($USiO_4$) and uraninite [UO_2(cr) or UO_2(a)] will also hinder their dissolution. Upon the cessation of dewatering, the Johnny M Mine would behave similarly to a saturated tailings deposit. Limited access of oxygen and the presence of organic matter (mainly humic materials present in the Westwater Canyon Member) would consume any small amounts of residual oxygen and produce a reducing environment (low Eh) that would stabilize and immobilize U and other constituents as mineral solids.

The overall water quality in the underground workings at the Johnny M Mine was monitored prior to and during backfilling with a sand slurry (and subsequent removal and treatment of the slurry water), that started in August of 1977 and was completed prior to cessation of mining activity in 1982. Subsequently, a sample was collected from the North Vent pipe in 1985 and some additional sampling of the groundwater quality in the Morrison Formation that hosts the backfilled underground workings has recently been conducted as part of the baseline water-quality evaluations being conducted for the proposed Roca Honda Project. The tailings slurry water had elevated concentrations of various constituents (i.e., arsenic, nitrate, molybdenum, selenium, vanadium, gross alpha, radium, thorium, U, chloride, sulfate, and TDS). However, the concentrations of these constituents observed in the underground workings were much lower as a result of immobilization under reducing geochemical conditions (the slurry water was initially oxidizing and in some cases mildly acidic), and because the slurry water was pumped from the mine, treated, and discharged. In the most recent sampling event for well 143, a well screened at a depth approximately coincident with the ore zone, all constituents either meet USEPA public drinking water system standards or are similar to background concentrations.

The historical data, coupled with the voluminous amount of data collected by the proposed Roca Honda project, allows for the assessment of probable impacts to surface and groundwater quality from the former Johnny M Mine.

Itasca is of the opinion that additional investigation of groundwater and surface-water quality in the vicinity of the Project Area is not technically warranted, as sufficient information exists to assess the probable impacts to surface and groundwater quality from the former Johnny M Mine, as discussed in this report.

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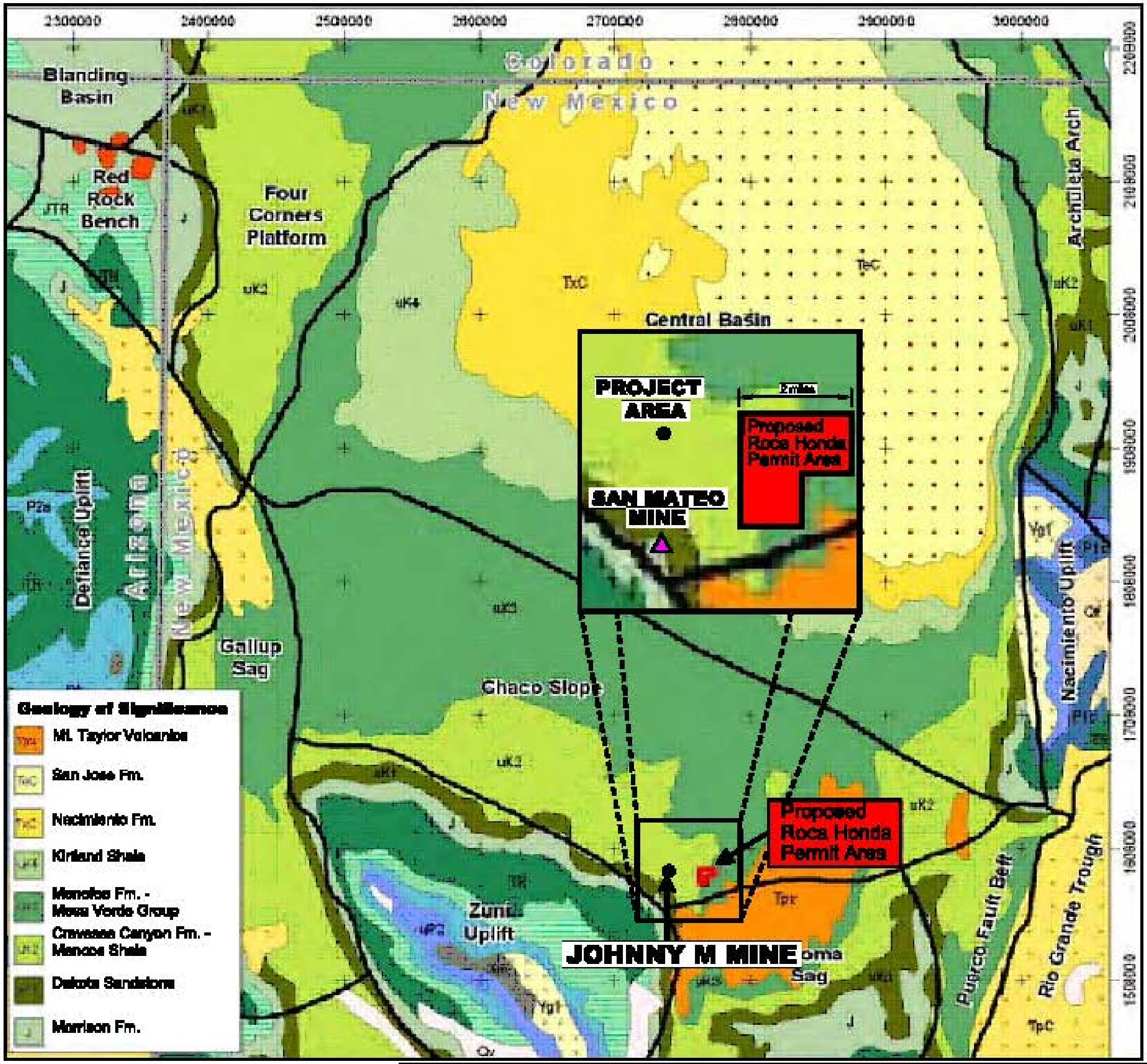
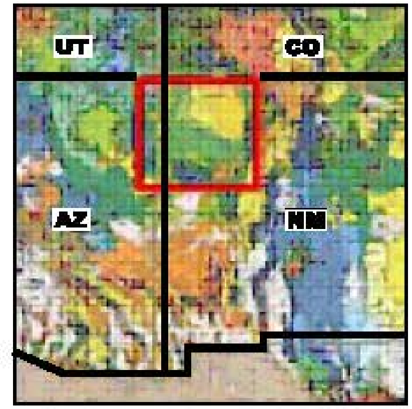




Red frame denotes area of detail to left

SOURCE: ADAPTED FROM
ROCA HONDA RESOURCES, LLC 2011

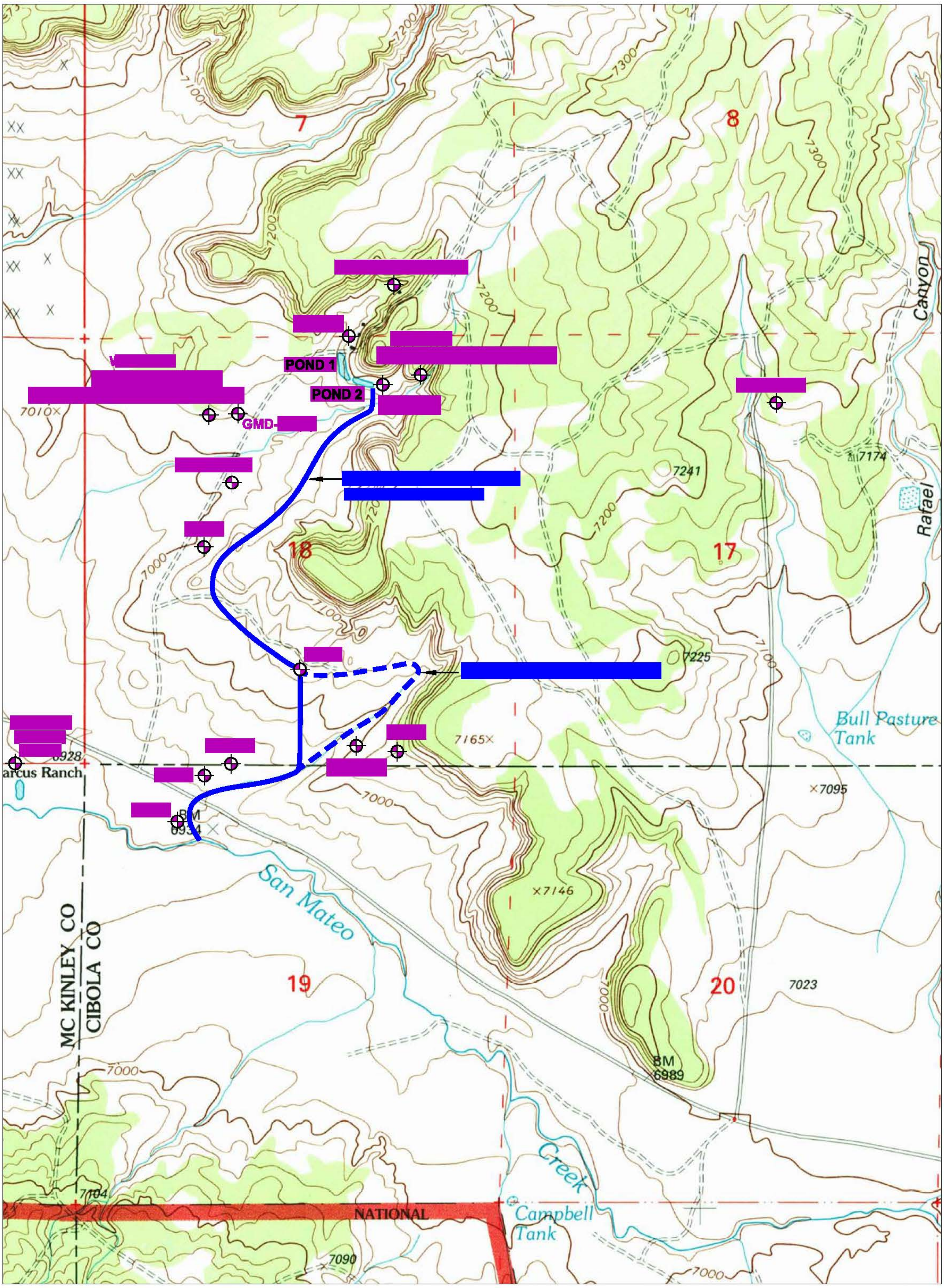
PROJECT NO.	1971
BY	OTHERS/RJS
CHECKED	RJS
DRAWN	OTHERS/SAC
DRAWING NAME	REGIONAL-GEOLOGY
DRAWING DATE	11 MAY 2012
REVISION DATE	15 MAR 2013

ITASCA™
Denver, Inc.

Regional Geology Map
of Northwestern New Mexico

CLIENT: Hecla Limited

FIGURE NO. 1



EXPLANATION

WATER-SAMPLING LOCATION

STARTING 3/1/78 EXISTING DRAINAGE CANAL REPLACED WITH 12-in DISCHARGE PIPE

0 — 1/4 SCALE (mile)

NOTE: LOCATION OF THE UNUSED WELL, GMD-05, AT THE FORMER JACKSON PROPERTY IS UNKNOWN.

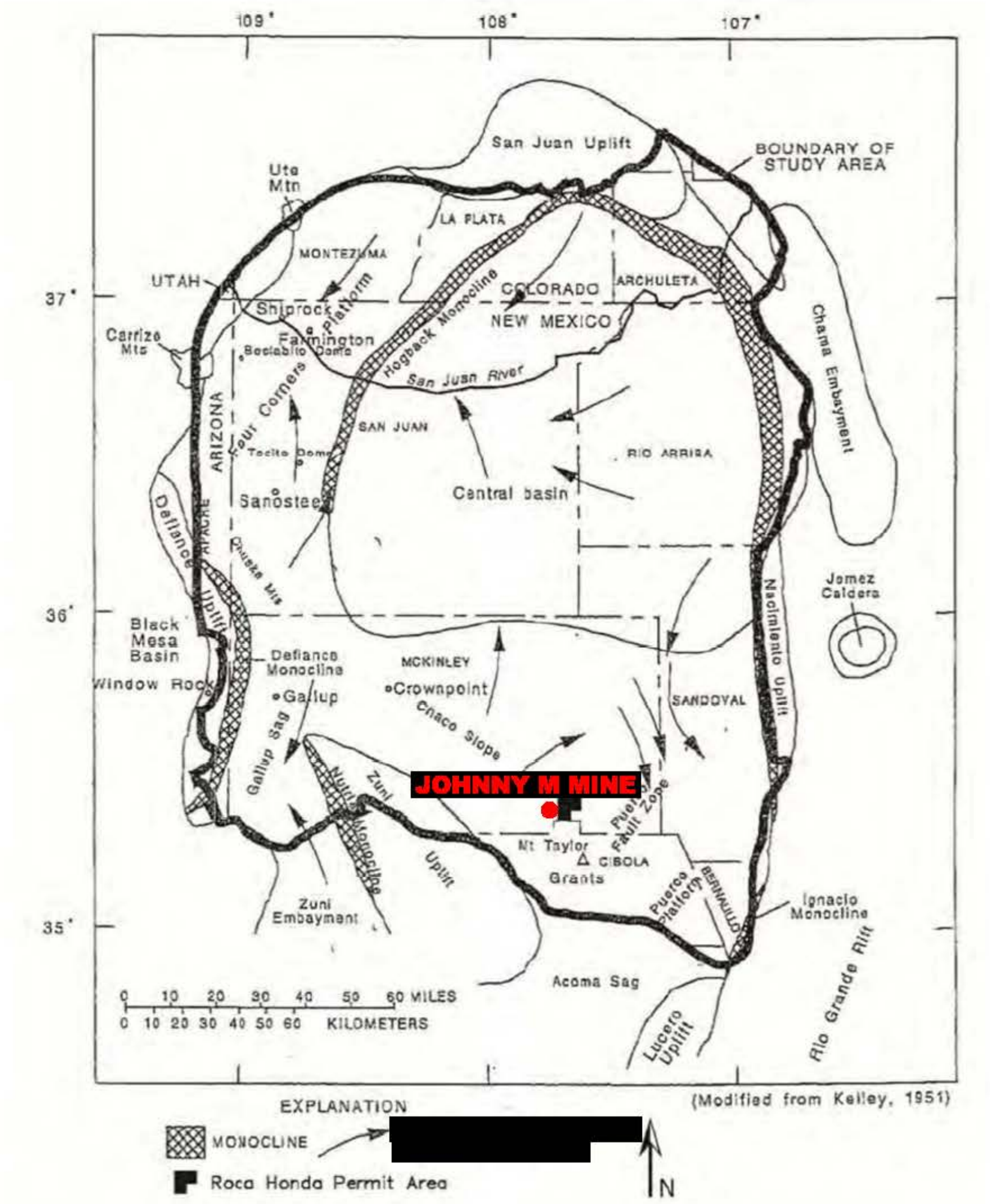
PROJECT NO.	1971
BY	RJS
CHECKED	RJS
DRAWN	SAC
DRAWING NAME GW-SW-SAMP-LOCS	
DRAWING DATE	11 MAY 2012
REVISION DATE	15 MAR 2013

ITASCA™ Denver, Inc.

Approximate Locations of Groundwater and Surface-Water Sampling Locations

CLIENT: Hecla Limited

FIGURE NO. 2



(Modified from Dam, 1995, Figure 2)

SOURCE: ADAPTED FROM ROCA HONDA RESOURCES, LLC 2011

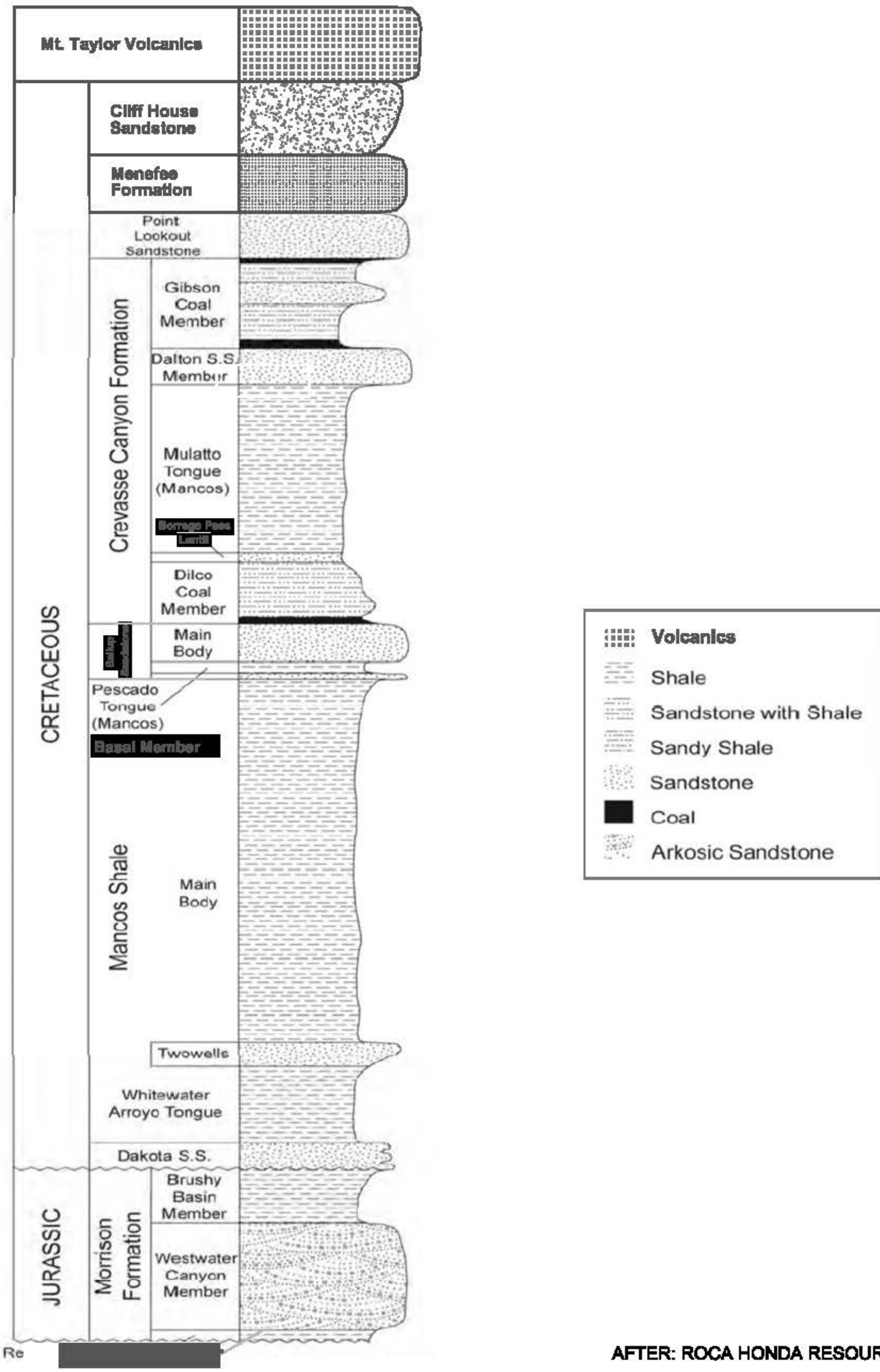
PROJECT NO.	1971
BY	OTHERS/RJS
CHECKED	RJS
DRAWN	OTHERS/SAC
DRAWING NAME	STRUCTURE
DRAWING DATE	11 MAY 2012
REVISION DATE	15 MAR 2013

ITASCA™ Denver, Inc.

Structural Elements of the San Juan Structural Basin and Adjacent Areas and Generalized Patterns of Groundwater Flow in Rocks of Jurassic and Cretaceous Ages

CLIENT: Hecla Limited

FIGURE NO. 3



AFTER: ROCA HONDA RESOURCES, LLC 2011

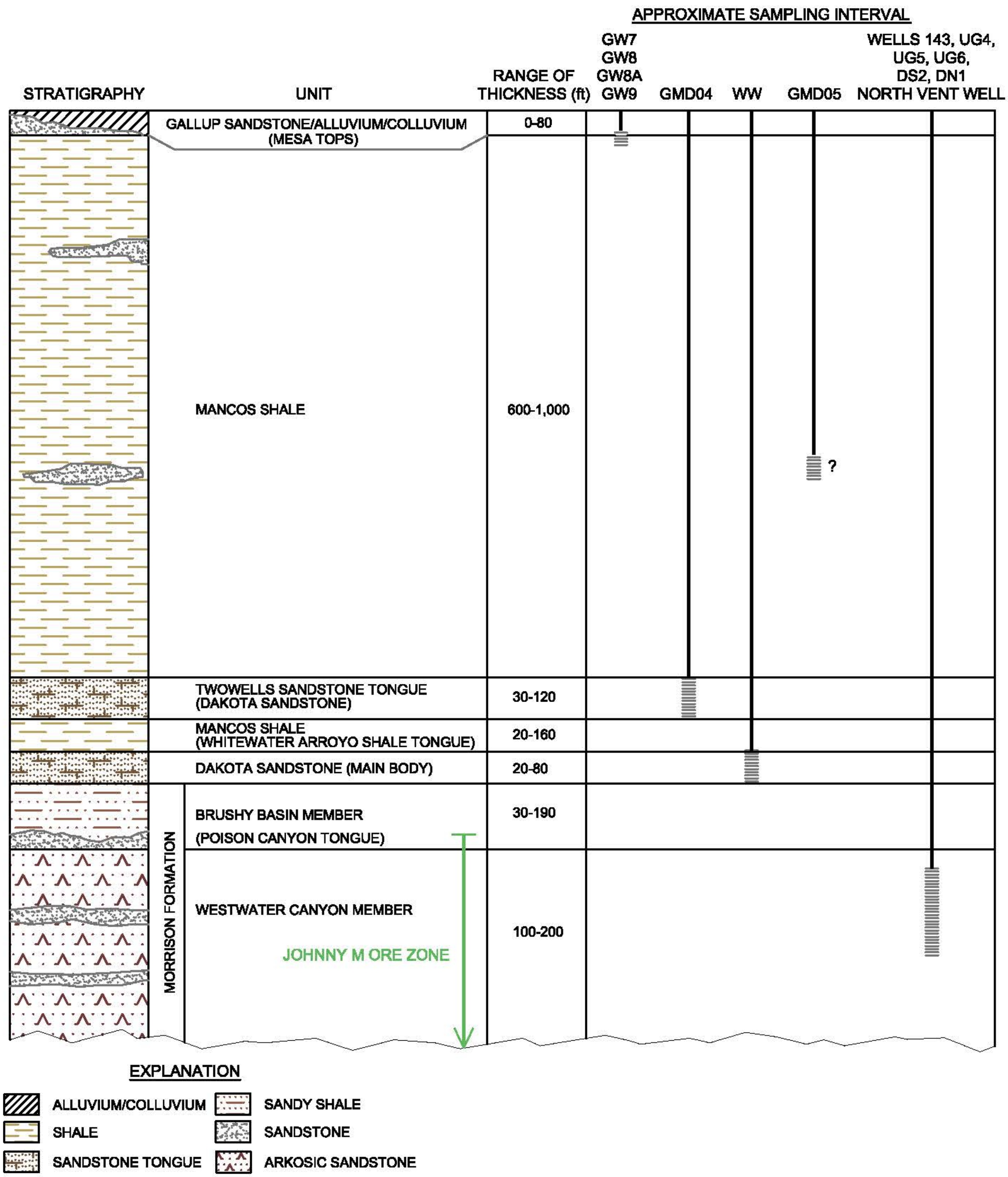
PROJECT NO.	1971
BY	OTHERS/RJS
CHECKED	RJS
DRAWN	OTHERS/SAC
DRAWING NAME	STRAT–PERMITAREA
DRAWING DATE	11 MAY 2012
REVISION DATE	15 MAR 2013

ITASCA™ Denver, Inc.

Typical Regional Stratigraphy within Approximately Five miles of Project Area

CLIENT: Hecla Limited

FIGURE NO. 4



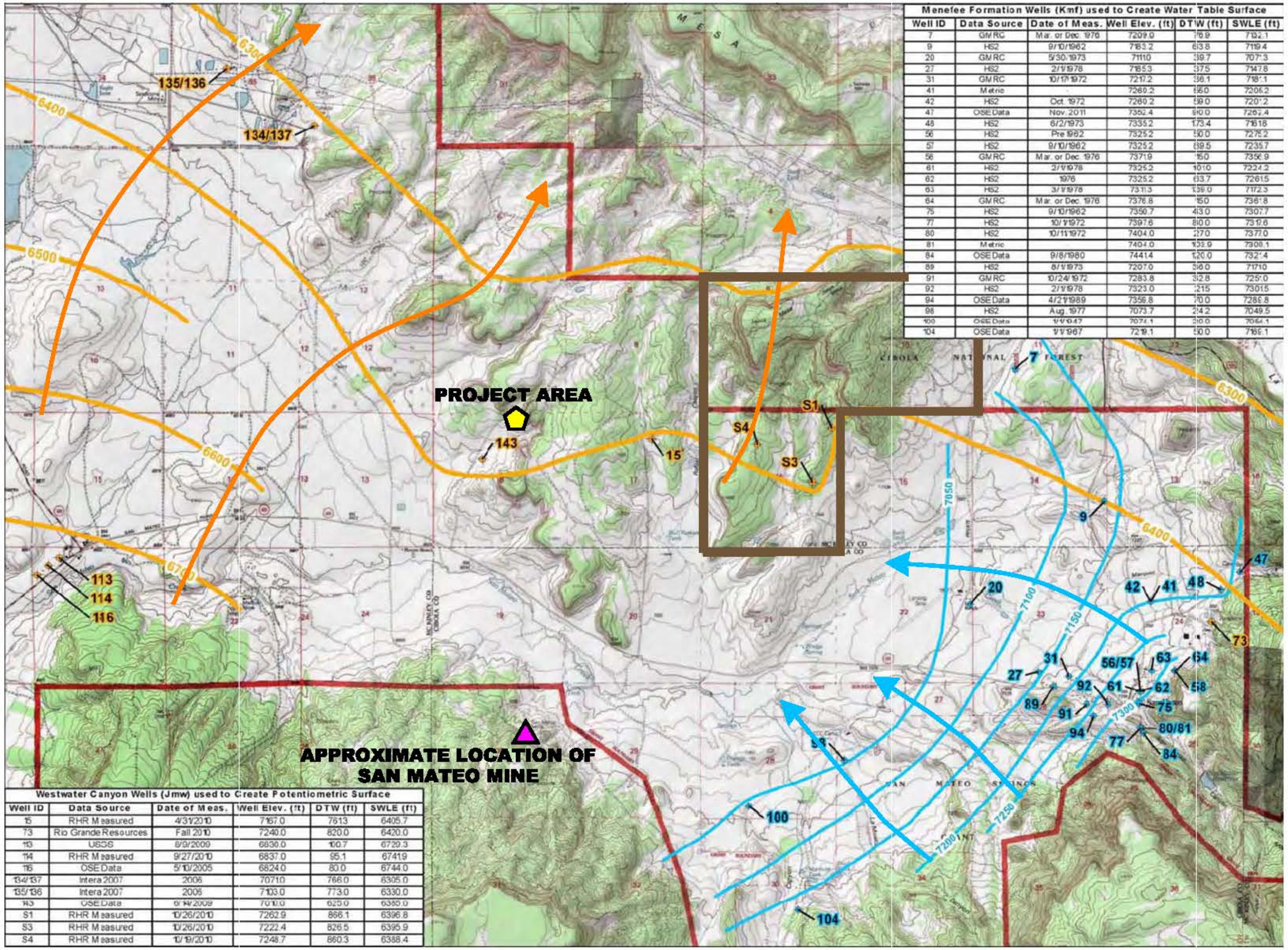
PROJECT NO.	1971
BY	BTH
CHECKED	RJS
DRAWN	SAC
DRAWING NAME	STRAT
DRAWING DATE	11 MAY 2012
REVISION DATE	15 MAR 2013

ITASCA™ Denver, Inc.

Generalized Stratigraphy of Johnny M Mine Project Area

CLIENT: Hecla Limited

FIGURE NO. 5



Menefee Formation Wells (Kmf) used to Create Water Table Surface					
Well ID	Data Source	Date of Meas.	Well Elev. (ft)	DTW (ft)	SWLE (ft)
7	GMRC	Mar. or Dec. 1976	7209.0	76.9	7132.1
9	HS2	9/10/1962	7183.2	63.8	7119.4
20	GMRC	5/30/1973	7111.0	39.7	7071.3
27	HS2	2/1/1978	7185.3	37.5	7147.8
31	GMRC	10/17/1972	7217.2	36.1	7181.1
41	Metric		7260.2	55.0	7205.2
42	HS2	Oct. 1972	7260.2	59.0	7201.2
47	OSE Data	Nov. 2011	7352.4	90.0	7262.4
48	HS2	6/2/1973	7335.2	173.4	7161.8
56	HS2	Pre 1962	7325.2	50.0	7275.2
57	HS2	9/10/1962	7325.2	89.5	7235.7
58	GMRC	Mar. or Dec. 1976	7371.9	15.0	7356.9
61	HS2	2/1/1978	7325.2	101.0	7224.2
62	HS2	1976	7325.2	63.7	7261.5
63	HS2	3/1/1978	7311.3	139.0	7172.3
64	GMRC	Mar. or Dec. 1976	7376.8	15.0	7361.8
75	HS2	9/10/1962	7350.7	43.0	7307.7
77	HS2	10/1/1972	7397.6	80.0	7317.6
80	HS2	10/11/1972	7404.0	27.0	7377.0
81	Metric		7404.0	103.9	7300.1
84	OSE Data	9/8/1980	7441.4	120.0	7321.4
89	HS2	8/1/1973	7207.0	36.0	7171.0
91	GMRC	10/24/1972	7283.8	32.8	7251.0
92	HS2	2/1/1978	7323.0	21.5	7301.5
94	OSE Data	4/21/1989	7356.8	70.0	7286.8
98	HS2	Aug. 1977	7073.7	24.2	7049.5
100	OSE Data	1/1/1947	7074.1	10.0	7064.1
104	OSE Data	1/1/1967	7219.1	50.0	7169.1

Westwater Canyon Wells (Jmw) used to Create Potentiometric Surface					
Well ID	Data Source	Date of Meas.	Well Elev. (ft)	DTW (ft)	SWLE (ft)
15	RHR Measured	4/31/2010	7167.0	761.3	6405.7
73	Rio Grande Resources	Fall 2010	7240.0	820.0	6420.0
113	USGS	8/9/2009	6830.0	100.7	6729.3
114	RHR Measured	9/27/2010	6837.0	95.1	6741.9
116	OSE Data	5/10/2005	6824.0	80.0	6744.0
134/137	Intera 2007	2006	7071.0	766.0	6305.0
135/136	Intera 2007	2006	7103.0	773.0	6330.0
143	OSE Data	6/14/2009	7010.0	625.0	6385.0
S1	RHR Measured	10/26/2010	7262.9	866.1	6396.8
S3	RHR Measured	10/26/2010	7222.4	826.5	6395.9
S4	RHR Measured	10/19/2010	7248.7	860.3	6388.4

SOURCE: ROCA HONDA RESOURCES, LLC 2011

State Plane Coordinate System
New Mexico, Western Zone, US Foot
NAD 83

Kmf Data Point (Menefee Formation)

Jmw Data Point (Morrison Formation, Westwater Canyon Member)

Kmf Water Table Contour (Menefee Formation)

Jmw Potentiometric Contour (Morrison Formation, Westwater Canyon Member)

0 0.25 0.5 1 Kilometers

0 0.25 0.5 1 Miles

Groundwater Flow Direction for Menefee Formation

Groundwater Flow Direction for Morrison Formation

Proposed Roca Honda Permit Area

PROJECT NO.	1971
BY	OTHERS/RJS
CHECKED	RJS
DRAWN	OTHERS/SAC
DRAWING NAME	MENEFEE-FM
DRAWING DATE	11 MAY 2012
REVISION DATE	15 MAR 2013

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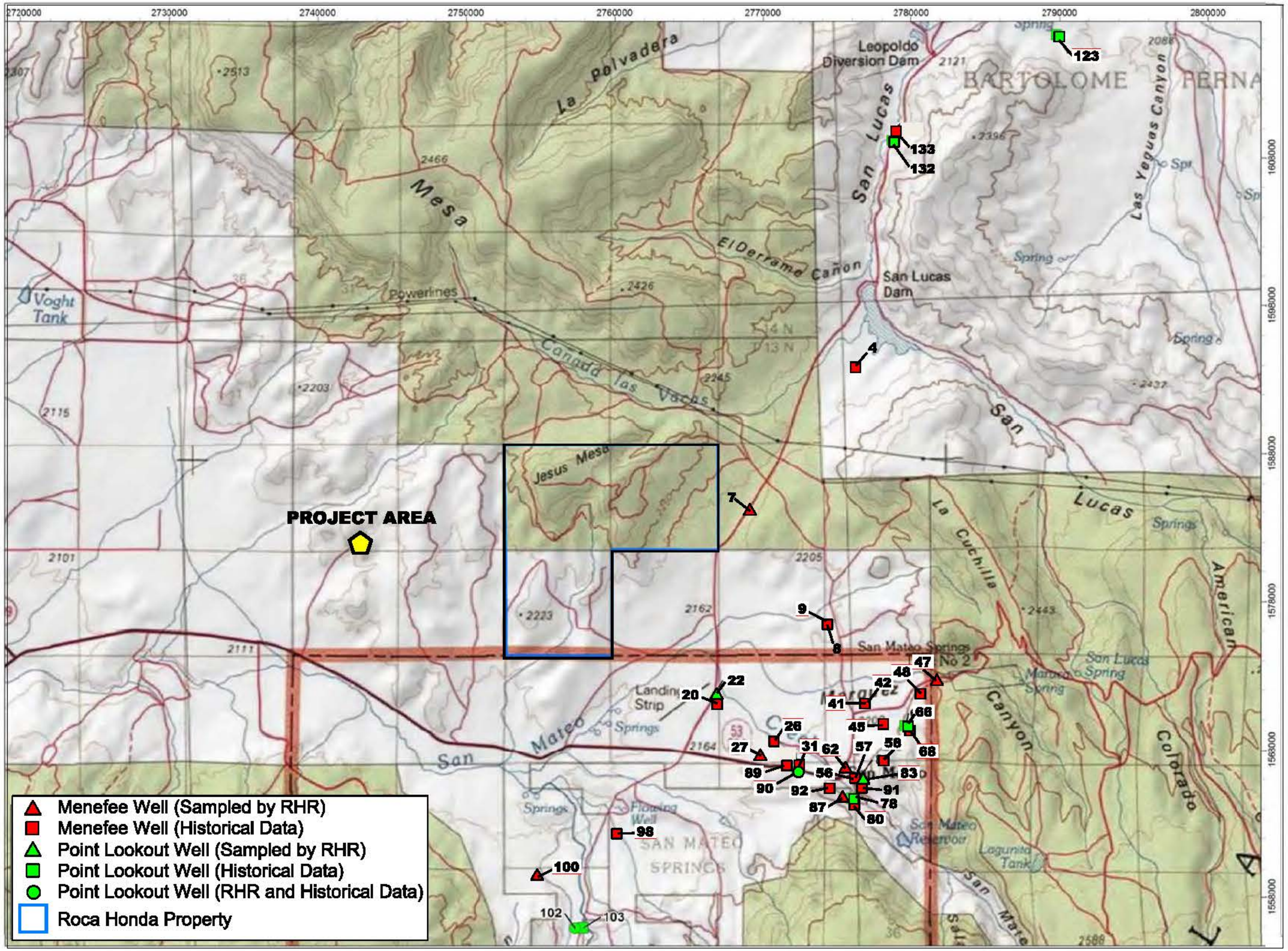
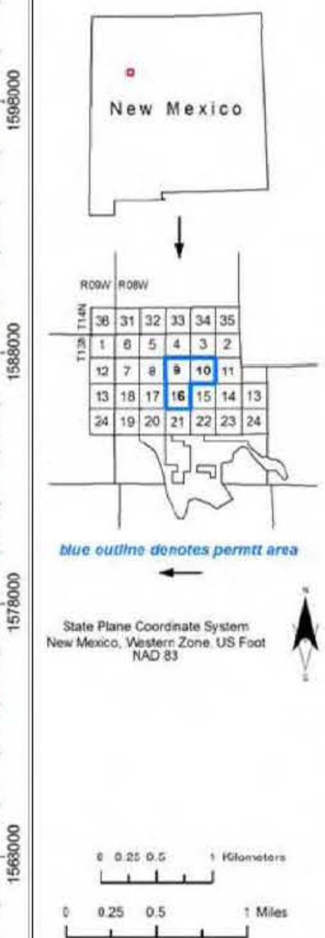
Modified Water-Table Surface for the Menefee Formation and Potentiometric Surface of Westwater Canyon Member Roca Honda / San Mateo Area

CLIENT: Hecla Limited

FIGURE NO. 6





NOTE:
MENEFEE FORMATION AND
POINT LOOKOUT SANDSTONE
ARE NOT PRESENT IN PROJECT AREA

SOURCE: ROCA HONDA RESOURCES, LLC 2011

PROJECT NO.	1971
BY	OTHERS/RJS
CHECKED	RJS
DRAWN	OTHERS/SAC
DRAWING NAME	WELL-LOCATIONS
DRAWING DATE	11 MAY 2012
REVISION DATE	15 MAR 2013

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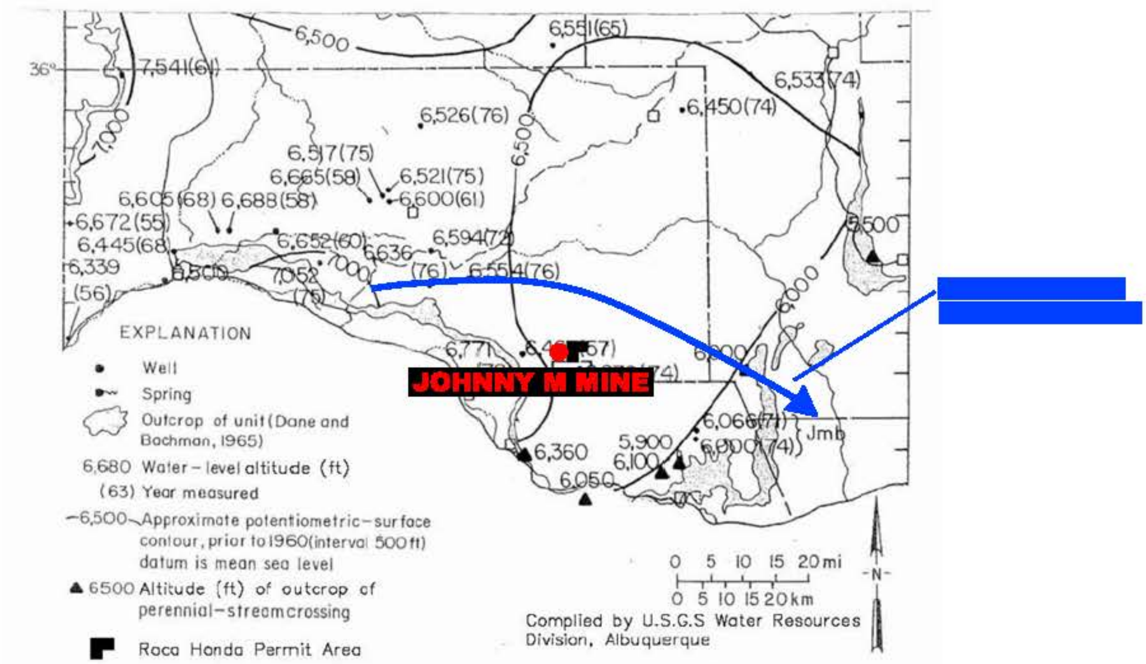
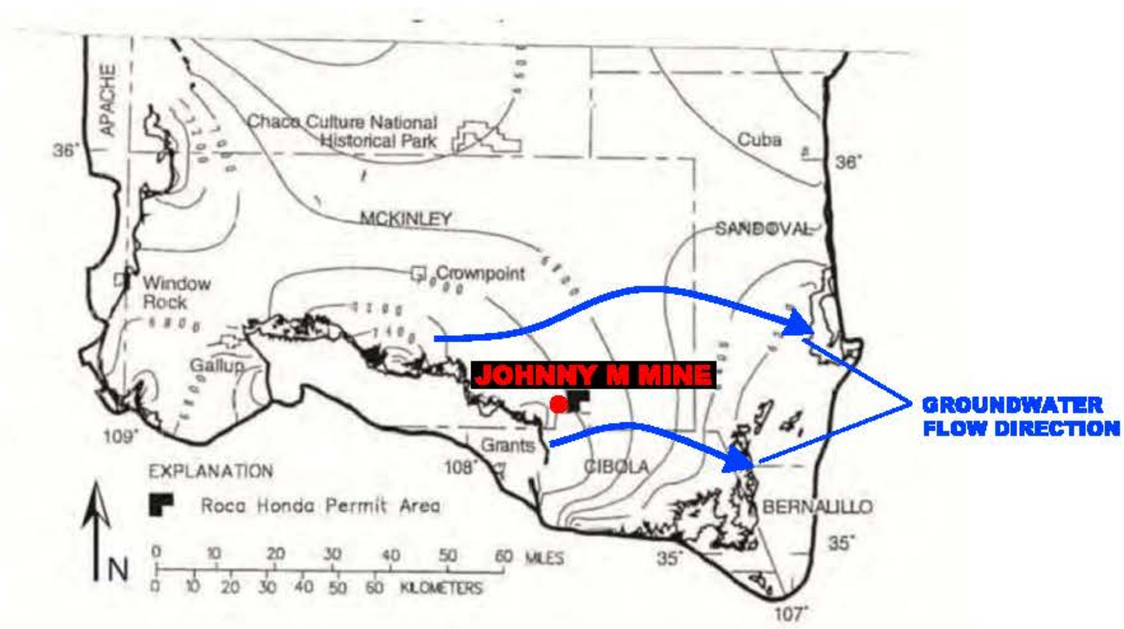
Locations of Menefee and Point Lookout Wells within 10 Miles of Project Area

CLIENT: Hecla Limited

FIGURE NO. 7



Water-Level Elevations and Potentiometric Surface for Westwater Canyon Member in the Southern Portion of the San Juan Basin (Modified from Stone et al. 1983, Figure 72)



Simulated Steady State Head in the Westwater Canyon Member (Modified from Kernodle 1996, Figure 52)

SOURCE: ADAPTED FROM ROCA HONDA RESOURCES, LLC 2011

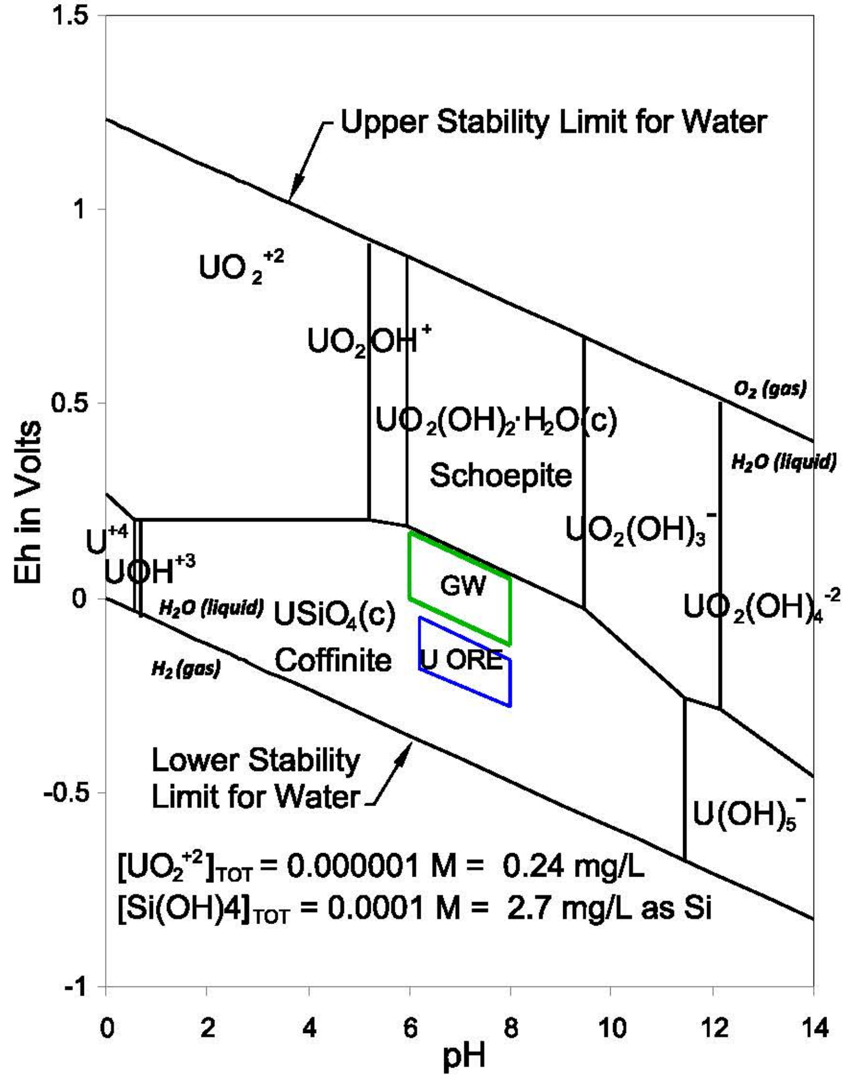
PROJECT NO.	1971
BY	OTHERS/RJS
CHECKED	RJS
DRAWN	OTHERS/SAC
DRAWING NAME	POTENTIOMETRIC
DRAWING DATE	11 MAY 2012
REVISION DATE	15 MAR 2013

ITASCA™ Denver, Inc.

Potentiometric Surfaces in Westwater Canyon Member with Groundwater Flow Directions

CLIENT: Hecla Limited

FIGURE NO. 8



Explanation

GW — Approximate Range of Regional Groundwater Discussed by Thomson et al. (1986)

U ORE — Approximate Range of Groundwater within Ore Zones by Thomson et al. (1986)

Note: The stability field for uraninite occupies a similar but smaller stability range to that illustrated for coffinite

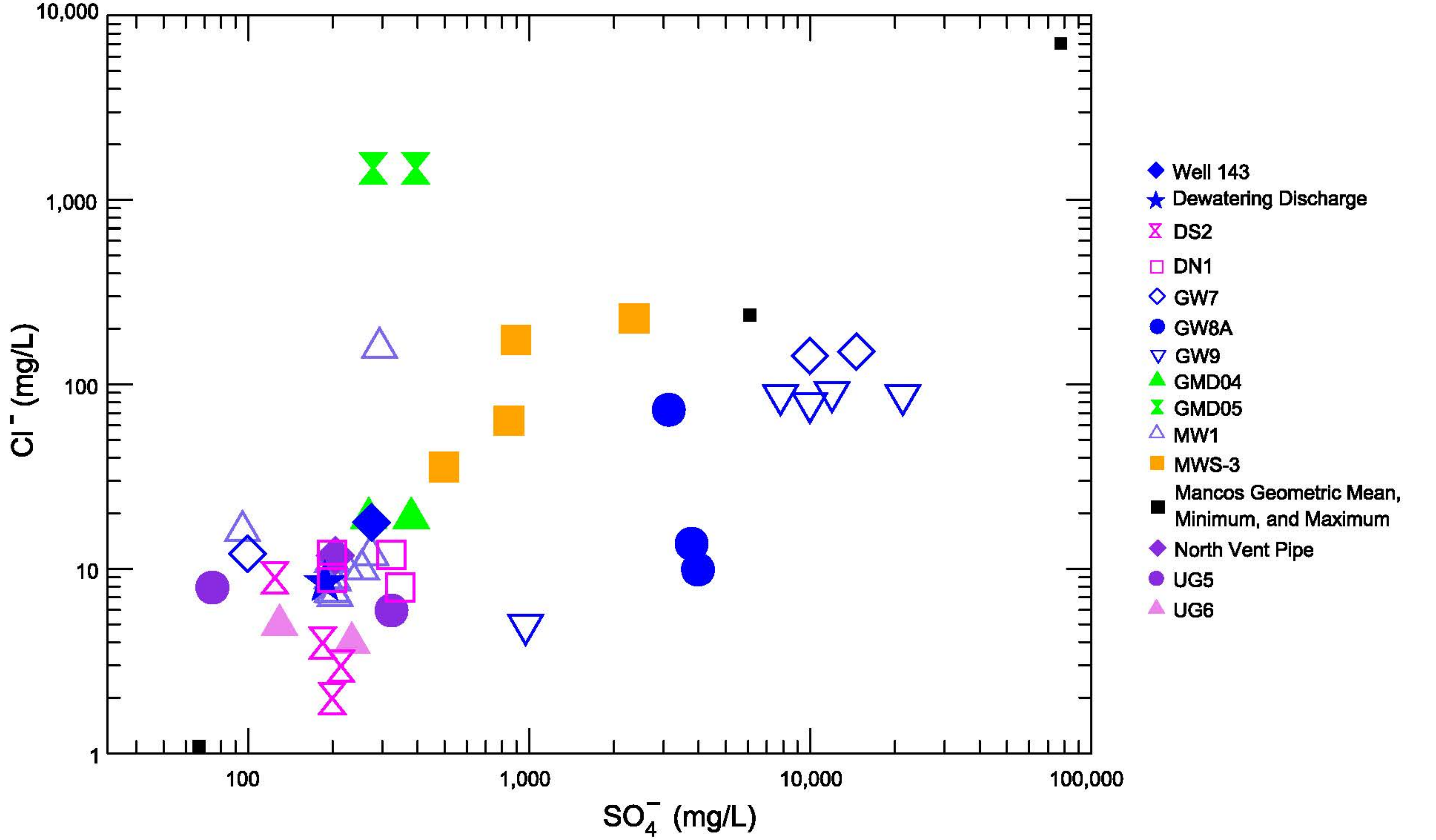
PROJECT NO.	1971
BY	JJM
CHECKED	RJS
DRAWN	SAC
DRAWING NAME	EH-PH
DRAWING DATE	11 MAY 2012
REVISION DATE	15 MAR 2013

ITASCA™ Denver, Inc.

Eh - pH Diagram for Uranium

CLIENT: Hecla Limited

FIGURE NO. 9



PROJECT NO.	1971
BY	BTH
CHECKED	RJS
DRAWN	SAC
DRAWING NAME	CHLORIDE–SULFATE
DRAWING DATE	11 MAY 2012
REVISION DATE	15 MAR 2013

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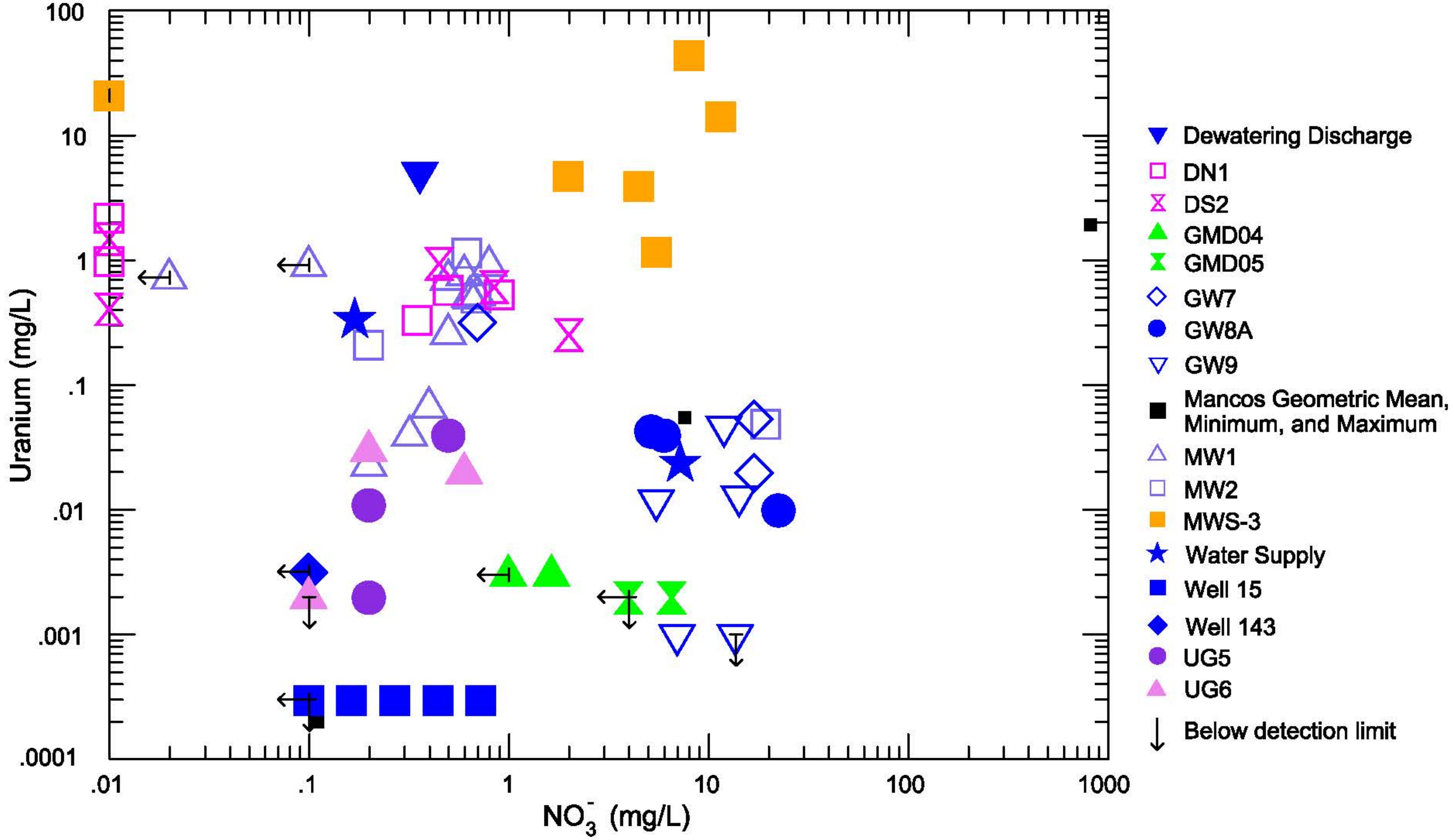
Denver, Inc.

Plot of Chloride and Sulfate Concentrations in Water Samples

CLIENT: Hecla Limited

FIGURE NO. 10



Note:
Some results from historical data reported as "U_3O_8", although the units appear to be mg/L average U. These older data may have comparability issues relative to recent data.

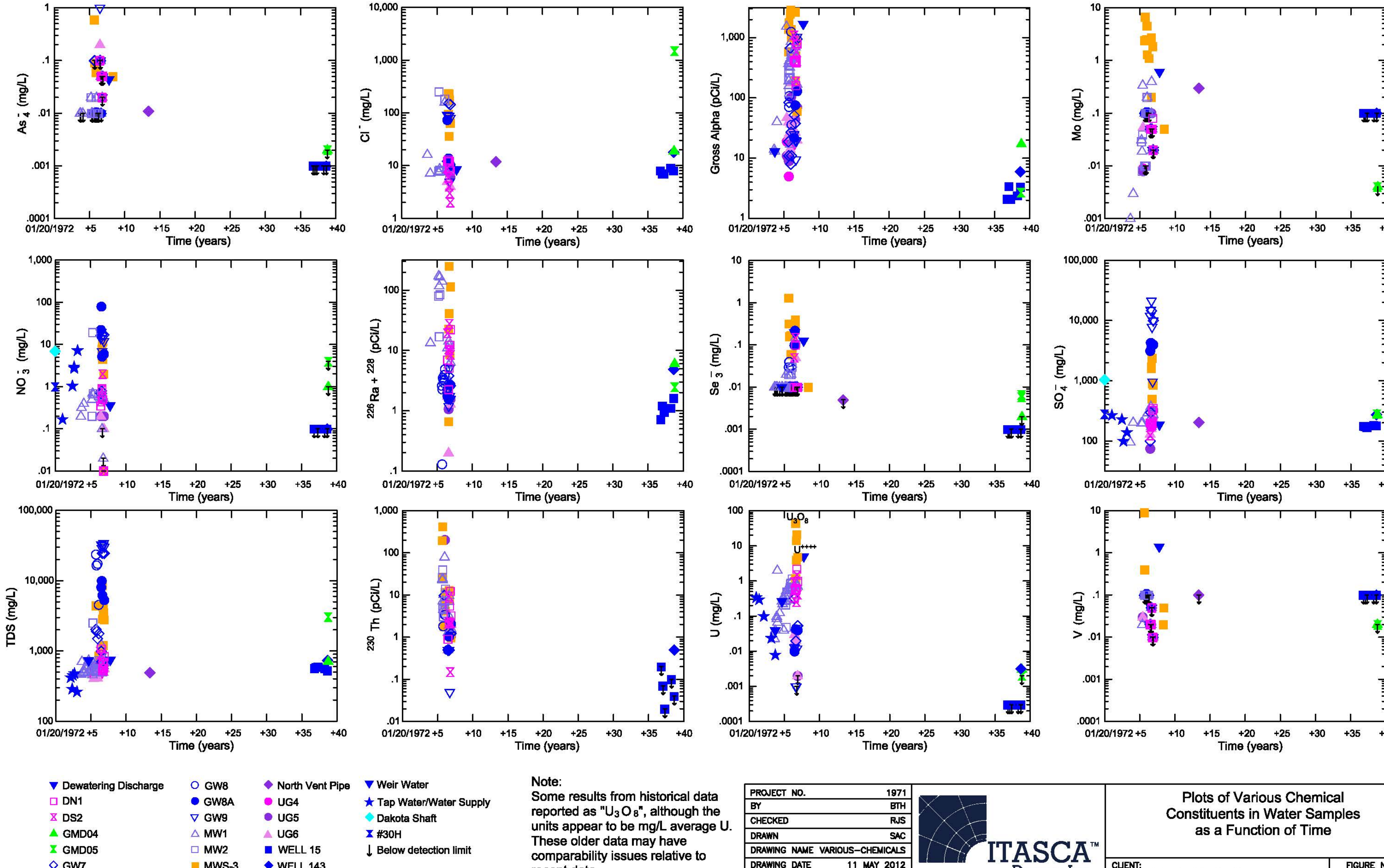
PROJECT NO.	1971
BY	BTH
CHECKED	RJS
DRAWN	SAC
DRAWING NAME	NITRATE–URANIUM
DRAWING DATE	11 MAY 2012
REVISION DATE	15 MAR 2013

ITASCA™
Denver, Inc.

Plot of Nitrate and Uranium Concentrations in Water Samples

CLIENT: Hecla Limited

FIGURE NO. 11



Note:
Some results from historical data reported as "U_3O_8", although the units appear to be mg/L average U. These older data may have comparability issues relative to recent data.

PROJECT NO.	1971
BY	BTH
CHECKED	RJS
DRAWN	SAC
DRAWING NAME	VARIOUS-CHEMICALS
DRAWING DATE	11 MAY 2012
REVISION DATE	15 MAR 2013

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Plots of Various Chemical Constituents in Water Samples as a Function of Time

CLIENT: Hecla Limited

FIGURE NO. 12

TABLE 1
Water-Sampling Location Summary

Location ID	Sample Location Type	Formation	Notes
Well 15	Groundwater	Westwater Canyon Member (Morrison Formation)	
Well 143	Groundwater	Westwater Canyon Member (Morrison Formation)	
#30H	?	?	Not used in analysis; data from Johnny M Mine records; location unknown
Dakota Shaft	Groundwater	Dakota Sandstone	
Discharged Water	Mine Water - Discharged	Not Applicable	Mine dewatering samples, collection point unknown
DN-1	Mine Water	Westwater Canyon Member (Morrison Formation)	Mine drainage ditch on north side of shaft prior to intersection of main underground sump
DS-2	Mine Water	Westwater Canyon Member (Morrison Formation)	Mine drainage ditch on south side of shaft prior to intersection of main underground sump
GMD-00	?	?	Not used in analysis; data from NMED/EPA Grants Mining District sampling; location unknown
GMD-01	?	?	Not used in analysis; data from NMED/EPA Grants Mining District sampling; location unknown
GMD-02	?	?	Not used in analysis; data from NMED/EPA Grants Mining District sampling; location unknown
GMD-03	?	?	Not used in analysis; data from NMED/EPA Grants Mining District sampling; location unknown
GMD-04 (Well 17)	Groundwater	Twowells Sandstone Tongue (Dakota Sandstone Interbed within Mancos Shale)	Former domestic well in Project Area; recently used as residential well
GMD-05	Groundwater	Sandstone Lens within Mancos Shale ?	Former domestic well in Project Area; recently unused
GW-7	Groundwater	Alluvium/Mancos Shale Contact	Monitoring well near mine discharge canal
GW-8	Groundwater	Alluvium/Mancos Shale Contact	Monitoring well near mine discharge canal
GW-8A	Groundwater	Alluvium/Mancos Shale Contact	Monitoring well near mine discharge canal
GW-9	Groundwater	Alluvium/Mancos Shale Contact	Monitoring well south of Tailings Pond #2
Mancos Geometric Mean	Groundwater	Mancos Shale	Data from Environmental Sciences Laboratory, 2011
Mancos Maximum	Groundwater	Mancos Shale	Data from Environmental Sciences Laboratory, 2011
Mancos Minimum	Groundwater	Mancos Shale	Data from Environmental Sciences Laboratory, 2011
Marcus Ranch Well	Groundwater	Alluvium	Data from Science Applications International Corporation, 1994
MW-1	Surface Water	Not Applicable	Sampling location at discharge of second of two settling ponds
MW-2	Surface Water	Not Applicable	Sampling location at discharge of drainage canal prior to entry to San Mateo Creek
MWS-3	Tailings Slurry Decant	Not Applicable	Water used to slurry backfill sands into mine
North Vent Pipe	Groundwater	Westwater Canyon Member (Morrison Formation)	Pipe inserted in the north vent pipe shaft to sample backfilled mine water
Tap Water	Groundwater	Dakota Sandstone	Water from Johnny M Mine potable well, collected at the tap
UG-4	Mine Water	Westwater Canyon Member (Morrison Formation)	Sampling location midway between north and south ore bodies
UG-5	Mine Water	Westwater Canyon Member (Morrison Formation)	Sampling location in northrern ore body
UG-6	Mine Water	Westwater Canyon Member (Morrison Formation)	Sampling location in southern ore body
Water Supply (WW)	Groundwater	Dakota Sandstone	Water from Johnny M Mine potable well, collection point unknown
Weir Water	Mine Water - Discharged	Not Applicable	Mine dewatering samples at discharge weir

TABLE 2
Water-Quality Results Compilation
(page 1 of 3)

Location ID	Sample Date	Arsenic	Selenium	TDS	Molybdenum	Vanadium	Radium 226	Radium 228	Radium (226 & 228)	Thorium 230	Lead 210	Lead	Gross Alpha	Zinc	Uranium	Uranium-234	Uranium-235	Uranium-238	Calcium	Magnesium	Potassium	Sodium	Chloride	pH	Sulfate	Alkalinity	U3O8	Nitrate (NO_3 as N)
		mg/l	mg/l	mg/l	mg/l	mg/l	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/l	pCi/L	mg/l	mg/l	pCi/L	pCi/L	pCi/L	mg/l	mg/l	mg/l	mg/l	mg/l	log[H]	mg/l		mg/l	mg/l
15	11/13/2008	< 0.001	< 0.001	567	< 0.1	< 0.1	0.25 +or - 0.13	0.47 +or - 0.73		< 0.2 +or - 0.10		< 0.05	2.1 +or - 1.6	0.1	< 0.0003				51	15	4	143	8	7.9	177	326		< 0.1
15	2/12/2009	< 0.001	< 0.001	588	< 0.1	< 0.1	0.43 +or - 0.18	0.78 +or - 0.73		< 0.07 +or - 0.08		< 0.05	3.4 +or - 1.6	0.15	< 0.0003				46	13	3	127	7	7.52	176	318		0.1
15	5/18/2009	< 0.001	< 0.001	591	< 0.1	< 0.1	<0.1 +or - 0.11	0.85 +or - 0.8		< 0.02 +or - 0.10		< 0.05	2.1 +or - 2	0.08	< 0.0003				48	14	4	136	7	7.81	169	331		< 0.1
15	4/28/2010	< 0.001	< 0.001	568	< 0.1	< 0.1	0.5 +or - 0.17	0.61 +or - 0.72		< 0.1 +or - 0.10		< 0.05	2.4 +or - 2.3	0.08	< 0.0003				47	13	4	135	9	7.63	181	347		< 0.1
15	9/20/2010	< 0.001	< 0.001	523	< 0.1	< 0.1	0.32 +or - 0.15	1.3 +or - 0.59		< 0.04 +or - 0.10		< 0.05	3.3 +or - 3.3	0.09	< 0.0003				45	12	4	139	8	7.85	180	356		< 0.1
143	9/23/2010	< nd	< nd	737	< nd	< nd	3.2	1.7 +or -		0.5		< nd	6	0.4	0.0032				105	21	4	104	18	7.89	276	295		< nd
#30H	26318																		122	23	6.8	160			280		nil	-1
Dakota Shaft	26318																		5.2	14.7	4.8	600			1050		nil	7
Discharged Water	Unknown		< 0.01	737			65.5 +or - 1.3							0.1	0.266													
DN-1	7/18/1978	< 0.1	< 0.01	1076	< 0.05	< 0.02			7.06 +or - 0.32	0.9 +or - 0.8	7.6 +or - 4.2	< 0.02	416 +or - 21	0.15									12	7.39	200		0.333	0.35
DN-1	8/13/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
DN-1	8/14/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
DN-1	9/13/1978	< 0.05	0.1	528	0.05	< 0.02			2.26 +or - 0.09	2.36 +or - 0.61	11.4 +or - 1.9	< 0.02	405 +or - 16	0.28									13	6.5	-		0.535	0.9
DN-1	9/14/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	190		-	-
DN-1	9/20/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
DN-1	10/19/1978	< 0.05	< 0.01	692	< 0.05	< 0.05			5.11 +or - 1.4	5.5 +or - 0.8	3.1 +or - 2	< 0.02	161 +or - 20	< 0.01									9	8.2	200		0.58	0.5
DN-1	11/16/1978	< 0.02	< 0.01	572	0.08	< 0.01			12.38 +or - 5.9	12.4	7.1 +or - 4.5	< 0.02	387 +or - 46	0.6									12	9.01	325		2.2	< 0.01
DN-1	12/21/1978	< 0.05	< 0.01	836	< 0.02	< 0.01			22.4 +or - 7.9	3.24 +or - 1.1	8.3 +or - 5	< 0.02	790 +or - 90	0.01									8	7.97	350		0.99	< 0.01
DS-2	7/18/1978	< 0.1	0.05	900	< 0.05	< 0.02			19.4 +or - 2.48	2.1 +or - 1.9	29.8 +or - 6.4	< 0.02	1092 +or - 95	0.5									9	7.33	125		0.946	0.45
DS-2	8/13/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
DS-2	8/14/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
DS-2	9/13/1978	< 0.05	0.15	560	0.05	< 0.02			10.46 +or - 1.3	9.4 +or - 1.2	22.6 +or - 2.4	< 0.02	907 +or - 33	0.23									6	6.42	-		0.618	0.85
DS-2	9/14/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	180		-	-
DS-2	9/20/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
DS-2	10/19/1978	< 0.05	< 0.01	693	< 0.05	< 0.05			27.98 +or - 25	2.1 +or - 0.2	3.5 +or - 2	< 0.02	190 +or - 25	< 0.01									4	8.12	185		0.255	2.01
DS-2	11/16/1978	< 0.02	< 0.01	560	0.02	< 0.01			10.09 +or - 9.8	0.15	5.3 +or - 4	< 0.02	591 +or - 60	0.21									3	8.45	215		1.5	< 0.01
DS-2	12/21/1978	< 0.05	< 0.01	524	< 0.02	< 0.01			8.5 +or - 0.64	2.16 +or - 0.93	5.8 +or - 6	< 0.02	410 +or - 45	0.01									2	8.77	200		0.41	0.01
GMD-00	11/8/2010	< 0.002	< 0.002		< 0.004	< 0.02						< 0.002		0.0488	< 0.002				3.12	1.04	< 1	13.7						
GMD-00	11/8/2010	< 0.002	< 0.002		< 0.004	< 0.02						< 0.002		0.0484	< 0.002				3.01	0.997	< 1	13.4		7				
GMD-00	11/8/2010						<0.752	<0.962					< 0.768			<0.414	< 0.127	< 0.213										
GMD-01	11/8/2010	0.0028	< 0.002		0.0051	< 0.02						< 0.002		< 0.02	< 0.002				46.6	13.6	4.31	23.8						
GMD-01	11/8/2010	0.0026	< 0.002		0.0047	< 0.02						< 0.002		< 0.02	< 0.002				45.6	13.3	4.32	23.4		7				
GMD-01	11/8/2010						<0.65	<0.979					1.28 +or - 0.767			1.598 +or - 0.552	0.147 +or - 0.168	0.864 +or - 0.387										
GMD-02	11/9/2010	0.0063	0.0294		0.0096	0.0232						< 0.002		< 0.02	0.0293				3.28	0.344	< 1	387						
GMD-02	11/9/2010	0.0066	0.0301		0.0091	0.0229						< 0.002		< 0.02	0.0292				3.27	0.345	< 1	385		8.7				
GMD-03	11/9/2010	0.0064	0.0299		0.0093	0.022						< 0.002		< 0.02	0.029				3.26	0.334	< 1	386						
GMD-03	11/9/2010	0.0063	0.0299		0.0088	0.0216						< 0.002		< 0.02	0.0279				3.17	0.338	< 1	370		8.7				
GMD-04	11/8/2010	< 0.002	< 0.002		< 0.004	< 0.02						< 0.002		0.474	0.003				104	21.3	4.11	104						
GMD-04	11/8/2010	< 0.002	< 0.002		< 0.004	< 0.02						< 0.002		0.432	0.003				100	20.5	3.92	99.8		7.4				
GMD-04	11/8/2010			709			3.33 +or - 1.15	2.67 +or - 0.75					17.3 +or - 4.01			1.255 +or - 0.476	< 0.238	0.877 +or - 0.385					19		270	270		< 1
GMD-05	11/8/2010	< 0.002	0.0058		< 0.004	< 0.02						< 0.002		< 0.02	< 0.002				16.6	4.61	4.54	1080						
GMD-05	11/8/2010	< 0.002	0.0066		< 0.004	< 0.02						< 0.002		< 0.02	< 0.002				17.6	4.89	7.22	1160		7.8				
GMD-05	11/8/2010			3070			1.05 +or - 0.71	1.39 +or - 0.57					< 2.67			<0.248	< 0.272	< 0.278					1500		280	390		< 4
GW-7	7/18/1978	0.1	< 0.01	992	0.05	< 0.02			2.3 +or - 0.8	< 0.5 +or - 0.1	< 1 +or - 0.5	< 0.02	52 +or - 5	0.3									12.2	6.6	100		0.32	0.7
GW-7	8/13/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	300		-	-
GW-7	8/14/1978	< 0.1	0.01	708	-	-			-	-	-	< 0.02	-	-									-	-	-		-	0.8
GW-7	9/13/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
GW-7	9/14/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
GW-7	9/20/1978	< 0.01	0.01	24740	< 0.05	< 0.05			3.81 +or - 0.78	< 0.5 +or - 0.1	< 1 +or - 0.5	0.4	38 +or - 2	0.02									152	6.56	14634		0.02	17
GW-7	10/19/1978	-	-	-	-	-			-	-	-		-	-									-	-	-		-	-
GW-7	11/16/1978	-	-	-	-	-			-	-	-		-	-									-	-	-		-	-
GW-7	12/21/1978	< 0.05	< 0.01	24592	< 0.02	< 0.01			2.62 +or - 5.2	1.23 +or - 0.8	7 +or - 5	0.04	960 +or - 100	0.14									144	7	10000		0.054	17
GW-7	9/30/1977	< 0.1	< 0.01	-	< 0.1	< 0.1	1.21 +or - 0.2			- -	8.2 +or - 6.6		19 +or - 8	-	-				-	-	-	-	-	-	-	-		-
GW-7	10/14/1977	< 0.1	0.01	2030	< 0.1	< 0.1	0.47 +or - 12			- -	50 +or - 11		11 +or - 4	-	-				-	-	-	-	-	-	-	-		-
GW-7	10/24/1977	< 0.1	< 0.01	-	< 0.1	< 0.1	0.81 +or - 0.2			- -	- -		85 +or - 33	-	-				-	-	-	-	-	-	-	-		-
GW-7	11/14/1977	< 0.01	< 0.01	1910	< 0.1	< 0.1	2.04 +or - 0.48			- -	- -		0 +or - 5	-	-				-	-	-	-	-	-	-	-		-
GW-7	12/7/1977	< 0.01	< 0.01	-	< 0.1	< 0.1	0.72 +or - 0.3			- -	- -		0 +or - 5	-	-				-	-	-	-	-	-	-	-		-
GW-7	1/6/1978	< 0.01	< 0.01	1506	< 0.1	< 0.1	138 +or - 6			9.83 +or - 3.06	15 +or - 9		678 +or - 121	-	-				-	-	-	-	-	-	-	-		-
GW-7	1/25/1978	< 0.01	0.01	-	< 0.1	< 0.1	3.85 +or - 0.45			- -	- -		8 +or - 6	-	-				-	-	-	-	-	-	-	-		-
GW-7	2/8/1978	< 0.01	0.03	-	< 0.1	< 0.1	1.23 +or - 0.31			- -	6 +or - 2		27 +or - 7	-	-				-	-	-	-	-	-	-	-		-
GW-7	3/9/1978	< 0.01	0.01	1770	< 0.1	< 0.1	1.68 +or - 0.28			- -	- -		11 +or - 5	-	-				-	-	-	-	-	-	-	-		-
GW-7	4/3/1978	< 0.01	0.01	-	< 0.1	< 0.1	- -			- -	- -		- -	-	-				-	-	-	-	-	-	-	-		-
GW-7	5/8/1978	< 0.01	< 0.01	-	< 0.1	< 0.1	- -			- -	- -		- -	-	-				-	-	-	-	-	-	-	-		-
GW-8	9/30/1977	< 0.01	0.03	-	< 0.1	< 0.1			2.61 +or - 0.31	-	10 +or - 6		0 +or - 2.5															
GW-8	10/14/1977	< 0.01	0.04	23722	< 0.1	< 0.1			0.13 +or - 0.09	-	-		0 +or - 4															
GW-8	10/24/1977	< 0.01	0.04	-	< 0.1	< 0.1			2.27 +or - 0.36	-	-		71 +or - 34															
GW-8	11/14/1977	< 0.01	< 0.01	16600	< 0.1	< 0.1			3.53 +or - 0.54	1.83 +or - 0.89	-		108 +or - 30															
GW-8	12/7/1977	< 0.01	< 0.01	-	< 0.1	< 0.1			3.33 +or - 0.49	-	-		0 +or - 26															
GW-8	1/6/1978	< 0.01	< 0.01	17500	< 0.1	< 0.1			2.93 +or - 0.43	-	-		0 +or - 29															
GW-8	1/25/1978	< 0.01	< 0.01	-	< 0.1	< 0.1			3.19 +or - 0.42	-	-		0 +or - 5															
GW-8	2/8/1978	< 0.01	< 0.01	-	< 0.1	< 0.1			3.97 +or - 0.55	3.41 +or - 1.57	7 +or - 2		1260 +or - 365															
GW-8	3/9/1978	< 0.01	< 0.01	4560	< 0.1	< 0.1			4.93 +or - 0.64	-	-		36 +or - 36															
GW-8	4/3/1978	< 0.01	< 0.01	-	< 0.1	< 0.1			-	-	-		-															
GW-8	5/8/1978	< 0.01	< 0.01	-	< 0.1	< 0.1			-	-	-		-															
GW-8A	7/18/1978	< 0.1	0.1	8080	< 0.05	< 0.02			1.75 +or - 0.6	< 0.5 +or - 0.1	< 1 +or - 0.5	0.02	22 +or - 3	0.5									73.6	8.54	3150		0.01	22.5
GW-8A	8/13/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	4300		-	-
GW-8A	8/14/1978	< 0.1	0.22	9968	-	-			-	-	-	0.35	-	-									-	-	-		-	80
GW-8A	9/13/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
GW-8A	9/14/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
GW-8A	9/20/1978	< 0.01	0.01	6212	< 0.05	< 0.05			1.56 +or - 0.54	1.05 +or - 0.5	< 1 +or - 0.5	0.05	76 +or - 2	0.14									13.8	8.05	3800		0.043	5.2
GW-8A	10/19/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
GW-8A	11/16/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
GW-8A	12/21/1978	< 0.05	< 0.01	5310	< 0.02	< 0.01			2.69 +or - 5.3	2.07 +or - 0.9	2.7 +or - 5	0.06	130 +or - 20	< 0.01									10	7.69	4000		0.04	6

Note: Water-quality data presented here are compiled from available analytical results from Johnny M Mine records provided by Hecla Mining Co. Highlighted values are questionable due to the illegibility of the original from which they were taken.

TABLE 2
Water-Quality Results Compilation
(page 2 of 3)

Location ID	Sample Date	Arsenic mg/l	Selenium mg/l	TDS mg/l	Molybdenum mg/l	Vanadium mg/l	Radium 226 pCi/L	Radium 228 pCi/L	Radium (226 & 228) pCi/L	Thorium 230 pCi/L	Lead 210 pCi/L	Lead mg/l	Gross Alpha pCi/L	Zinc mg/l	Uranium mg/l	Uranium-234 pCi/L	Uranium-235 pCi/L	Uranium-238 pCi/L	Calcium mg/l	Magnesium mg/l	Potassium mg/l	Sodium mg/l	Chloride mg/l	pH log[H]	Sulfate mg/l	Alkalinity	U3O8 mg/l	Nitrate (NO_3 as N) mg/l
GW-9	7/18/1978	1	0.2	33088	< 0.05	< 0.02			1.81 +or- 0.6	< 0.5 +or- 0.1	< 1 +or- 0.5	0.25	25 +or- 4	2.6									91.4	4.66	12000		0.013	14.3
GW-9	8/13/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	15000		-	-
GW-9	8/14/1978	0.1	0.2	29280	-	-			-	-	-	21.5	-	-									-	-	-		-	20
GW-9	9/13/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
GW-9	9/14/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
GW-9	9/20/1978	< 0.01	0.01	31880	< 0.05	< 0.05			1.2 +or- 0.53	< 0.5 +or- 0.1	< 1 +or- 0.5	0.45	20 +or- 1	2.1									88	5.22	21425		0.001	7
GW-9	10/19/1978	< 0.05	< 0.01	32032	< 0.05	< 0.05			5.05 +or- 0.89	< 0.05 +or- 0.01	< 1 +or- 0.5	0.2	9.5 +or- 5	1.2									88	4.83	7869		< 0.001	13.7
GW-9	11/16/1978	< 0.02	< 0.01	34252	< 0.02	< 0.01			1.77 +or- 0.75	0	< 1 +or- 0.5	0.5	19.4 +or- 10	1.86									5	4.24	975		0.012	5.5
GW-9	12/21/1978	< 0.05	< 0.01	30432	< 0.02	< 0.01			1.58 +or- 6.1	1.13 +or- 0.7	4.3 +or- 5.5	0.72	1040 +or- 101	1.6									80	4.75	10000		0.047	12
Mancos Geometric Mean		0.0011	0.0827			0.0006									0.0553	24.3		11.9	336	392	14.3	1692	238	7.4	6114			7.6
Mancos Minimum		0.0002	0.0001			0.0002									0.0002	0.2	0	0.1	48	6.2	0.9	9.3	1.1	4.2	67	0		0.1
Mancos Maximum		0.0229	7.557			0.0190									1.922	489	15	280	600	7000	71.5	25000	7098	8.5	78003	1726		816
Marcus Ranch Well	7/1/1993	< 0.005	< 0.01		< 0.02	< 0.01	0.2 +or- 0.28					< 0.01	6 +or- 15		0.0035									7.6				
MW-1	9/15/1975	< 0.01	< 0.01	468	< 0.001		3.85	-				< 0.001	14 +or- 7	0.517	0.023								16.2		96			0.2
MW-1	10/20/1975	< 0.01	< 0.01	709			2.92	-				< 0.001	13 +or- 9	-	0.04								-		-			0.32
MW-1	12/29/1975	-	< 0.01	491		-	10.3	-				-		-	0.0978								-		-			
MW-1	1/15/1976	-	< 0.01	536			93.2	-				-		-	0.085								-		-			
MW-1	2/2/1976	-	< 0.01				17.5	-				-		-	2.005								-		-			
MW-1	2/11/1976	< 0.01	< 0.01	511	0.003		13.5	0				< 0.001	40.5	0.016	0.0672								7.2		205			0.4
MW-1	6/2/1976	-	< 0.01	545			40.9	-				-		-	0.125								-		-			
MW-1	9/29/1976	-	< 0.01	737			65.5	-				-		-	0.266								-		-			
MW-1	11/3/1976	-	< 0.01	541			70.7	-				-		-	0.227								-		-			
MW-1	12/13/1976	-	-				102	-				-		-	0.33								-		-			
MW-1	1/4/1977	-	-				6.8	-				-		-	0.0403								-		-			
MW-1	2/7/1977	-	-				7.1	-				-		-	0.395								-		-			
MW-1	3/16/1977	-	< 0.01	571			65.5	-				-		-	0.278								-		-			
MW-1	4/15/1977	0.02	< 0.01	460	0.031		172	<1				< 0.001		< 0.01	0.26								7.6		200			0.5
MW-1	5/16/1977	< 0.01	0.02	503	0.019		117	<1				< 0.001		0.007	0.531								7.5		202			0.7
MW-1	6/15/1977	< 0.01	0.01	515	0.34	0.02	165	1				< 0.001	1540 +or- 40	< 0.01	0.516								8.7		202			0.64
MW-1	9/30/1977	0.01	0.01		< 0.1	< 0.1	97.4 +or- 2.4	-		23.2 +or- 2.6	96 +or- 10	-	370 +or- 30	-	-								-		-			
MW-1	10/14/1977	0.01	0.02	504	< 0.1	< 0.1	141 +or- 3	1		24.5 +or- 0.1	< 3.3	-	192 +or- 14	-	-								-		-			
MW-1	10/24/1977	0.01	0.01		0.1	< 0.1	135 +or- 4	-		7.26 +or- 2.64		-	161 +or- 23	-	-								-		-			
MW-1	11/14/1977	0.01	0.01	528	< 0.1	< 0.1	182 +or- 4	-		4.56 +or- 1.24	0 +or- 2	-	417 +or- 33	-	0.58								-		-			
MW-1	12/7/1977	0.01	0.01		< 0.1	< 0.1	30.4 +or- 1.8	-		10.3 +or- 2.3	14 +or- 6	-	321 +or- 34	-	0.85								-		-			
MW-1	1/6/1978	0.01	0.01	526	< 0.1	< 0.1	2.13 +or- 0.32	-		-	7.2 +or- 5.1	-	17 +or- 11	-	0.287								-		-			
MW-1	1/25/1978	0.02	0.02		0.2	0.1	90.6 +or- 3.9	-		79.5 +or- 4.9		-	410 +or- 67	-	0.65								-		-			
MW-1	2/8/1978	0.01	-		0.2	< 0.1	-	-		4.29 +or- 1.58	0 +or- 2	-	861 +or- 102	-	-								-		-			
MW-1	3/9/1978	-	-	700	0.1	< 0.1	-	-		3.49 +or- 2.42	8 +or- 2	-	515 +or- 80	0.01	-								160		295			
MW-1	4/3/1978	-	-		0.1	< 0.1	-	-				-		-	-								-		-			
MW-1	5/8/1978	-	-		0.1	< 0.1	-	-				-		-	-								-		-			
MW-1	7/18/1978	< 0.1	< 0.01	1236	< 0.05	< 0.02			11.1 +or- 2.4	1.3 +or- 1.9	9.7 +or- 5.1	< 0.02	618 +or- 32	0.3									9	7.33	200		0.502	0.65
MW-1	8/13/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	375		-	-
MW-1	8/14/1978	< 0.1	< 0.01	488	-	-			-	-	-	< 0.02	-	-									-	-	-		-	0.7
MW-1	9/13/1978	< 0.05	0.15	524	0.1	< 0.02			14.33 +or- 1.02	9.76 +or- 1.1	12.6 +or- 2.1	< 0.02	485 +or- 17	0.04									11	6.58	-		0.915	0.8
MW-1	9/14/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	175		-	-
MW-1	9/20/1978	< 0.01	< 0.01	632	0.4	< 0.05			5.77 +or- 2.05	7.1 +or- 1	9.8 +or- 5	0.08	706 +or- 11	0.06									10	7.1	255		0.91	< 0.1
MW-1	10/19/1978	< 0.05	< 0.01	808	< 0.05	< 0.05			12.27 +or- 2.5	3 +or- 0.2	5.2 +or- 3	< 0.02	759 +or- 65	< 0.01									11	8.25	200		0.775	0.6
MW-1	11/16/1978	< 0.02	< 0.01	616	0.02	< 0.01			3 +or- 6	0	4.7 +or- 3	< 0.02	155 +or- 20	0.18									10	9.2	225		0.725	< 0.02
MW-1	12/21/1978	< 0.05	< 0.01	684	< 0.02	< 0.01			6.36 +or- 8.6	1.62 +or- 0.8	5 +or- 6	< 0.02	170 +or- 10	< 0.01									12	8.54	275		0.71	0.5
MW-2	4/15/1977	0.02	< 0.01	548	0.029	-	79.4	<1			-	< 0.001	-	< 0.01	0.211								7.9	8.3				0.2
MW-2	5/16/1977	< 0.01	< 0.01	2520	0.008	-	9.9	7.2			-	< 0.001	-	0.026	0.049								252	8.09				19.4
MW-2	6/15/1977	< 0.01	0.01	522	0.039	-	84	1			-	< 0.001	-	0.01	0.502								8.3	8.14				0.69
MW-2	9/30/1977	0.01	0.02	-	< 0.01	< 0.1	115 +or- 3	-		25.8 +or- 0.5	12 +or- 7	-	300 +or- 30	-	-								-	-				-
MW-2	10/14/1977	0.01	0.02	511	< 0.01	< 0.1	120 +or- 5	-		39.9 +or- 0.1	0 +or- 2	-	211 +or- 14	-	-								-	-				-
MW-2	10/29/1977	< 0.01	0.01	-	0.1	< 0.1	66.7 +or- 3.1	-		4.82 +or- 1.82	-	-	123 +or- 20	-	-								-	-				-
MW-2	11/15/1977	0.01	0.01	505	< 0.01	< 0.1	156 +or- 4	-		3.1 +or- 1.76	16 +or- 6	-	354 +or- 30	-	0.65								-	-				-
MW-2	12/7/1977	0.01	0.01	-	< 0.01	< 0.1	27.9 +or- 1.5	-		3.05 +or- 1.25	0 +or- 2	-	265 +or- 31	-	0.825								-	-				-
MW-2	1/6/1978	0.02	0.01	536	< 0.1	< 0.1	7.49 +or- 0.57	-		0 +or- 0.2	0 +or- 2	-	221 +or- 51	-	0.891								-	-				-
MW-2	1/25/1978	0.02	0.02	680	0.2	< 0.1	16.2 +or- 1.1	-		6.02 +or- 1.91	-	-	385 +or- 64	-	-								-	-				-
MW-2	2/8/1978	0.01	0.01	-	0.1	< 0.1	110 +or- 3	-		7.21 +or- 2.77	8.8 +or- 54	-	583 +or- 59	-	0.695								-	-				-
MW-2	3/9/1978	0.01	0.03	732	0.1	< 0.1	51 +or- 2	-		14 +or- 4.3	7 +or- 1	< 0.05	471 +or- 63	0.01	1.15								185	8.35				0.62
MW-2	4/3/1978	0.01	0.01	-	0.1	< 0.1	-	-		-	-	-	-	-	0.68								-	-				-
MW-2	5/8/1978	< 0.01	< 0.01	-	< 0.1	< 0.1	-	-		-	-	-	-	-	-								-	-				-
MWS-3	9/30/1977	0.59	1.3	-	2.4	9	177 +or- 3			197 +or- 6	160 +or- 13		1380 +or- 60															
MWS-3	10/14/1977	0.09	0.32	4410	0.1	0.4	24.5 +or- 1			26.7 +or- 0.5	0 +or- 2		589 +or- 84															
MWS-3	10/24/1977	0.01	0.16	-	6.7	< 0.1	640 +or- 9			417 +or- 16	-		1807 +or- 163															
MWS-3	1/6/1978	0.06	0.17	-	2.5	< 0.1	192 +or- 7			1.8 +or- 1.58	50 +or- 15		2484 +or- 173															
MWS-3	1/25/1978	< 0.01	0.06	-	4.5	< 0.1	132 +or- 4			6.72 +or- 0.9	-		2894 +or- 199															
MWS-3	2/8/1978	< 0.01	< 0.01	-	1.3	< 0.1	242 +or- 4			11.8 +or- 3.8	36 +or- 2		1383 +or- 141															
MWS-3	3/9/1978	< 0.01	0.06	856	0.1	< 0.1	19.9 +or- 1.5			4.19 +or- 2.37	10 +or- 1		1014 +or- 114															
MWS-3	5/8/1978	< 0.01	0.16	-	1.1	< 0.1	-			-	-		-															
MWS-3	7/18/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
MWS-3	8/13/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
MWS-3	8/14/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
MWS-3	9/13/1978	< 0.05	0.3	2876	2.7	< 0.02			22.9 +or- 2.48	13 +or- 2.4	36.4 +or- 7.8	< 0.02	2686 +or- 90	0.32									94.4	6.25	-		44.2	8
MWS-3	9/14/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	1600		-	-
MWS-3	9/20/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
MWS-3	10/19/1978	< 0.05	< 0.01	4288	< 0.05	< 0.05			252.1 +or- 6	12 +or- 1	27.3 +or- 7	< 0.02	929 +or- 90	< 0.01									230	7.55	2375		14.25	11.6
MWS-3	11/16/1978	< 0.02	< 0.01	3536	1.84	< 0.01			8.68 +or- 6.5	0	21.8 +or- 8	< 0.02	862 +or- 80	0.92									176	7.8	900		21	< 0.01
MWS-3	12/21/1978	< 0.05	< 0.01	2792	< 0.02	< 0.01			115 +or- 19	0.99 +or- 0.7	15.8 +or- 7	< 0.02	60 +or- 80	0.05									64	7.83	850		4.8	2
MWS-3	7/18/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
MWS-3	8/13/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
MWS-3	8/14/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
MWS-3	9/13/1978	< 0.05	0.4	8548	0.2	< 0.02			0.66 +or- 0.08	2.46 +or- 0.71	13.2 +or- 4	< 0.02	194 +or- 10	0.64									232	5.4	-		1.175	5.5
MWS-3	9/14/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	1700		-	-
MWS-3	9/20/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
MWS-3	10/19/1978		< 0.01	1200	< 0.05	< 0.05			41.36 +or- 3.6	7.7 +or- 0.5	17 +or- 5	< 0.02	503 +or- 60	< 0.01									36	8.22	500		3.95	4.5
MWS-3	11/16/1978		-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
MWS-3	12/21/1978		< 0.01	-	-	-			-	-	-	-	-	-									-	-	-		-	-

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TABLE 2
Water-Quality Results Compilation
(page 3 of 3)

Location ID	Sample Date	Arsenic mg/l	Selenium mg/l	TDS mg/l	Molybdenum mg/l	Vanadium mg/l	Radium 226 pCi/L	Radium 228 pCi/L	Radium (226 & 228) pCi/L	Thorium 230 pCi/L	Lead 210 pCi/L	Lead mg/l	Gross Alpha pCi/L	Zinc mg/l	Uranium mg/l	Uranium-234 pCi/L	Uranium-235 pCi/L	Uranium-238 pCi/L	Calcium mg/l	Magnesium mg/l	Potassium mg/l	Sodium mg/l	Chloride mg/l	pH log[H]	Sulfate mg/l	Alkalinity	U3O8 mg/l	Nitrate (NO_3 as N) mg/l
North Vent Pipe	6/19/1985	0.011	< 0.005	495	0.3	< 0.1						< 0.1		< 0.1					6.3 or 48	15 or 24.9			11.9		205			
Tap Water	Unknown			480															35	11.4				7.72	100			2.77
Tap Water	27687						2.34 +or- 0.23						0 +or- 2		0.008													
UG-4	7/5/1977	< 0.01	< 0.01	452	0.009	0.03	2.7 +or- 0.03			-	-		19 +or- 5															
UG-4	9/30/1977	< 0.01	< 0.01	-	< 0.1	< 0.1	2.7 +or- 0.29			-	-		11 +or- 7															
UG-4	10/14/1977	< 0.01	< 0.01	469	< 0.1	< 0.1	3.29 +or- 0.35			-	-		5 +or- 3															
UG-4	10/29/1977	< 0.01	< 0.01	-	< 0.1	< 0.1	2.09 +or- 0.28			-	-		9 +or- 6															
UG-4	11/15/1977	< 0.01	< 0.01	468	< 0.1	< 0.1	3.16 +or- 0.41			-	-		10 +or- 5															
UG-4	12/7/1977	< 0.01	< 0.01	-	< 0.1	< 0.1	0.49 +or- 0.29			-	-		0 +or- 5															
UG-4	1/6/1978	< 0.01	< 0.01	430	< 0.1	< 0.1	0 +or- 0.05			-	-		0 +or- 5															
UG-4	2/8/1978	< 0.01	< 0.01	-	< 0.1	< 0.1	2.92 +or- 0.47			-	-		18 +or- 3															
UG-4	3/9/1978	< 0.01	< 0.01	454	< 0.1	< 0.1	1.49 +or- 0.4			-	-		16 +or- 5															
UG-4	4/3/1978	< 0.01	< 0.01	-	< 0.1	< 0.1	-			-	-		-															
UG-4	5/8/1978	< 0.01	< 0.01	-	< 0.1	< 0.1	-			-	-		-															
UG-4	1/25/1978	< 0.01	< 0.01	-	< 0.1	< 0.1	5.75 +or- 0.06			-	-		18 +or- 9															
UG-5	7/5/1977	< 0.01	< 0.01	567	0.008	0.03	5.9 +or- 0.6			-	-		11 +or- 5															
UG-5	9/30/1977	< 0.01	< 0.01	-	< 0.1	< 0.1	1.09 +or- 0.22			-	-		11 +or- 7															
UG-5	10/14/1977	< 0.01	< 0.01	609	< 0.1	< 0.1	0.68 +or- 0.17			-	-		9 +or- 5															
UG-5	10/29/1977	< 0.01	< 0.01	-	< 0.1	< 0.1	1.79 +or- 0.35			-	-		9 +or- 6															
UG-5	11/15/1977	< 0.01	< 0.01	640	< 0.1	< 0.1	4.94 +or- 0.49			-	9.7 +or- 7.7		11 +or- 4															
UG-5	12/7/1977	< 0.01	< 0.01	-	< 0.1	< 0.1	1.01 +or- 0.22			-	0 +or- 2		0 +or- 5															
UG-5	1/6/1978	< 0.01	< 0.01	570	< 0.1	< 0.1	0.8 +or- 0.18			-	-		0 +or- 5															
UG-5	1/25/1978	< 0.01	< 0.01	-	< 0.1	< 0.1	1.86 +or- 0.28			-	-		0 +or- 5															
UG-5	2/8/1978	< 0.01	< 0.01	-	< 0.1	< 0.1	2.05 +or- 0.4			204 0.9	6 +or- 2		103 +or- 11															
UG-5	3/9/1978	< 0.01	< 0.01	680	< 0.1	< 0.1	0.79 +or- 0.3			-	-		20 +or- 7															
UG-5	4/3/1978	< 0.01	< 0.01	-	< 0.1	< 0.1	-			-	-		-															
UG-5	5/8/1978	< 0.01	< 0.01	-	< 0.1	< 0.1	-			-	-		-															
UG-5	7/18/1978	< 0.1	< 0.01	908	< 0.05	< 0.02			2.1 +or- 0.6	< 0.5 +or- 1	< 1 +or- 0.5	< 0.02	26 +or- 3	0.3									8	7.38	75		0.011	0.2
UG-5	8/13/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
UG-5	8/14/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
UG-5	9/13/1978	< 0.05	0.1	632	0.1	< 0.02			1.07 +or- 0.09	1.66 +or- 0.4	< 1 +or- 0.5	< 0.02	44 +or- 5	0.22									10.4	6.48	-		0.04	0.5
UG-5	9/14/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	175		-	-
UG-5	9/20/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
UG-5	10/19/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
UG-5	11/16/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
UG-5	12/21/1978	< 0.05	< 0.01	728	< 0.02	< 0.01			1.56 +or- 5.7	1.08 +or- 0.5	< 1 +or- 0.5	< 0.02	70 +or- 10	0.01									6	8.62	325		0.002	0.2
UG-6	7/5/1977	< 0.01	< 0.01	407	0.054	0.03	5.8 +or- 0.6			-	-		47 +or- 8															
UG-6	9/30/1977	< 0.01	< 0.01	-	< 0.1	< 0.1	6.17 +or- 0.48			-	9.9 +or- 6.7		40 +or- 11															
UG-6	10/14/1977	< 0.01	< 0.01	459	< 0.1	< 0.1	6.26 +or- 0.47			-	-		13 +or- 6															
UG-6	10/29/1977	< 0.01	< 0.01	-	< 0.1	< 0.1	7.39 +or- 0.5			-	-		23 +or- 3															
UG-6	11/15/1977	< 0.01	< 0.01	440	< 0.1	< 0.1	10.1 +or- 0.9			-	12 +or- 6		26 +or- 6															
UG-6	12/7/1977	< 0.01	< 0.01	-	< 0.1	< 0.1	0 +or- 0.1			-	12 +or- 6		0 +or- 5															
UG-6	1/6/1978	< 0.01	< 0.01	414	< 0.1	< 0.1	4.69 +or- 0.61			-	-		14 +or- 9															
UG-6	1/25/1978	< 0.01	< 0.01	-	< 0.1	< 0.1	97.8 +or- 4			4.81 +or- 0.39	-		178 +or- 31															
UG-6	2/8/1978	< 0.01	< 0.01	-	< 0.1	< 0.1	4.17 +or- 0.57			-	5 +or- 2		37 +or- 5															
UG-6	3/9/1978	< 0.01	< 0.01	516	< 0.1	< 0.1	5.36 +or- 0.76			-	-		28 +or- 5															
UG-6	4/3/1978	< 0.01	< 0.01	-	< 0.1	< 0.1	-			-	-		-															
UG-6	5/8/1978	< 0.01	< 0.01	-	< 0.1	< 0.1	-			-	-		-															
UG-6	7/18/1978	0.2	< 0.01	832	< 0.05	< 0.02			1.75 +or- 0.6	< 0.5 +or- 0.1	< 1 +or- 0.5	< 0.02	42 +or- 4	0.2									5	7.26	130		0.03	0.2
UG-6	8/13/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
UG-6	8/14/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
UG-6	9/13/1978	< 0.05	0.05	496	0.05	< 0.02			0.2 +or- 0.07	1.02 +or- 0.32	< 1 +or- 0.5	< 0.02	27 +or- 3	0.02									9.2	6.36	-		0.02	0.6
UG-6	9/14/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	160		-	-
UG-6	9/20/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
UG-6	10/19/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
UG-6	11/16/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
UG-6	12/21/1978	< 0.05	< 0.01	560	< 0.02	< 0.01			1.28 +or- 5.5	2.02 +or- 0.8	< 1 +or- 0.5	0.1	20 +or- 1	< 0.01									4	8.54	235		< 0.002	0.1
Water Supply (WW)	Unknown														0.024				40	8					140			7.26
Water Supply (WW)	Unknown			265										< 0.1					38	7.3	5.6	11.8		7.11				
Water Supply (WW)	Unknown			480										0.2					34	11.4				7.65	100			2.99
Water Supply (WW)	Unknown			453										< 0.1					33	11.6	7	55		7.21	230			1.05
Water Supply (WW)	Unknown			290										< 0.1					4	6.9	8.5	60		7.1				
Water Supply (WW)	26846																										0.3	
Water Supply (WW)	27089																										0.1	
Water Supply (WW)	Unknown			423															22	11.1	10.4	63		7.6				
Water Supply (WW)	Unknown																		40	53					270		0.34	0.17
Weir Water	27687						2.92 +or- 0.26						13 +or- 9		0.04													

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